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ABSTRACT

This teaching guide is one of a series developed by the Curriculum Research and Development Group at the University of Hawaii. The program is laboratory and field oriented for elementary students. The focus of study for the project is the plant and animal life and the physical components of the Hawaiian environment, and their ecological interrelationships. The program stresses student on-site observations, experimentation, discussion, and learning by experience. It is designed to fit within the science curriculum but can correlate with other subject areas in school, as well as with local community interests. This particular guidebook contains a sequence of observations and investigations about plant structures with vocabulary, procedures, and teacher background information specific to the given topics. The observations are concerned with stems, leaves, roots, flowers, fruits, vegetables, and seeds. There are numerous illustrations to help the teacher. This project series also includes a program namual that gives additional information about the philosophy and use of the Hawaii Nature Study Program. (Author/MA)

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HAWAII

NATURE STUDY PROGRAM

FOR ELEMENTARY SCHOOL CHILDREN

PARTS OF PLANTS

Teacher's Guide

A project of

CURRICULUM RESEARCH AND DEVELOPMENT GROUP
University Laboratory School
UNIVERSITY OF HAWAII
1776 University Avenue
Honolulu, Hawaii 96822

PARTS OF PLANTS

HAWAII NATURE STUDY PROJECT

by the

CURRICULUM RESEARCH AND DEVELOPMENT GROUP
UNIVERSITY OF HAWAII

Assisted by the HAWAIIAN ACADEMY OF SCIENCE
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THE HAWAII NATURE STUDY PROGRAM

The Hawaii Nature Study Program is a laboratory- and field-oriented program for elementary students. The focus of study is the plant and animal life and the physical components of the Hawaiian environment, and their ecological relationships. The program stresses student on-site observations, experimentation, discussion, and learning by experience.

The Hawaii Nature Study Program is designed to fit within the science curriculum but it correlates with other subject areas in school as well as with local community interests. It promotes awareness, appreciation, knowledge, and understanding of the environment. The specific skills it develops prepares students for science courses in the intermediate school.

THE PROGRAM MANUAL

The Hawaii Nature Study PROGRAM MANUAL, separately bound, contains a complete description of the program and its goals, together with an explanation of the BAND levels, suggested teaching strategies, and teaching aids for managing campus and neighborhood investigations, data analyses, and student reports.

Before putting this booklet of activities on PARTS OF PLANTS into classroom use, a teacher is advised to become well acquainted with the contents of the PROGRAM MANUAL. Order as a separate item through the project office. See front cover for address.

PARTS OF PLANTS

PARTS OF PLANTS Teacher's Guide contains a sequence of observations and investigations about plant structures with vocabulary, procedures, and teacher background information specific to the given topics.

This series of activities about plant parts is designed to help teachers bring to children:

1. enjoyable experiences and awareness of neighborhood plants in their myriad variety of colors, shapes, and arrangements;

2. some basic knowledge about plant structure. Knowledge of structure is a basic tool needed later for understanding plant relationships and dealing with plant classification and identification.

PARTS OF PLANTS

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1. MEASURING TREE TRUNKS. BANDS 1, 2, 3.

Introduction.

Since plants renew themselves through a complete cycle in each plant generation, it is difficult to say which point in the cycle is the best one with which to begin. This book starts with tree trunks on the basis that these are large, obvious features which young people can easily confront. Then comes stems to which logically can be attached other parts of plants: namely roots, leaves, flowers, fruits, seeds. A teacher who so desires can start at any other place in the growth cycle and come around full circle.

The first exercise on plant parts has the dual role of establishing an atmosphere in which nature study can most fruitfully flourish, and of introducing the subject of plants to the students.

The strategy for establishing nature study attitudes include:

1. Getting the children out-of-doors and accustomed to using the campus and neighborhood locale as their nature study laboratory.

2. Setting the "tone" for nature studies. The "tone" includes a happy atmosphere of shared hard work; and a willingness and courage to offer ideas of one's own as well as listen to others.

3. Initiating some of the science skills, beginning in this lesson with observation, critical consideration of procedures, proper data logging, and orderly report writing.

See the PROGRAM MANUAL for goals which the Nature Study Project aims to achieve in students.

As an introduction to the subject of plant study, students may be told that the purpose of this exercise is simply to get some measurements of the campus tree trunks. Just the excitement of doing something out-of-doors is usually enough to motivate the lesson. More academic reasons for studying plants emerge after the students have been exposed to several plant investigations and interest in the plants themselves begins to unfold.

Alternatives to Measuring Tree Trunks.

In some rare spots in Hawaii, trees within walking distance of the campus or at the students' homes are scarce. Since the goals of this introductory lesson concern attitudes and processes more than specific information about tree trunks, this exercise can be carried out by measuring the circumference of bushes, or the height of hedges. Simply substitute "shrub" or "hedge" for "tree trunk" and proceed with the lesson.

Band Levels.

Measuring Tree Trunks can serve all three BAND levels. The mathematics involved, the data logging, and the student notebook reporting can be omitted for BAND 1, or pursued to any desired degree up to an advanced elementary level.

Time Frame.

Probably one class period for the planning and the outdoor measurements.

Follow up time for BANDS 2 and 3 for data and notebook work.

Materials.

-Trees on campus or in the neighborhood or at the students' homes.
-Notebooks for BANDS 2 and 3 students.

Problem:

What size are tree trunks on our campus?

What shape, color, and texture are the trunks?

Procedures-in-Brief.

Here, as throughout the Nature Study Program, procedures are given in brief as a suggested outline for carrying out the activities; and then repeated in detail for the benefit of those teachers who prefer to have details.

1. Prepare for taking the class out-of-doors. Set up assignments for measuring tree trunks.

2. Children go outside, measure, note roughness, colors, other qualities of trunks.

3. Discuss observations. Digress either here or later into the need of standards in measuring.

4. If this is the first exercise of the year, instruct students in how data tables and notebook reports are to be set up during the Nature Study course. See PROGRAM MANUAL.

Procedures in Detail.

1. Prepare for going out-of-doors.

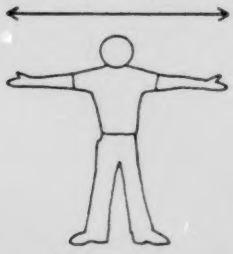
Before introducing this topic, look over the campus and neighborhood area to see where and about how many trees there are and decide whether you need to add or substitute shrubs or hedges. Plan whether the students are to work individually or by teams, in one area or different areas.

To begin the class, ask the children what they use to measure the length or size of something. (They may offer ruler, yard stick, etc.) Ask them how they could measure something if they did not have rulers or any such instruments. They may, or may not, think about using the span of their hands or string.

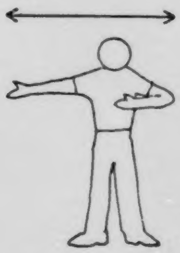
Tell them how the early Hawaiians and English measured. The following story can be simplified to suit younger classes, or given greater detail for older children. Illustrate on the blackboard as you talk, or prepare an overhead transparency to go with the story.

A Story about Ancient Standards of Measure

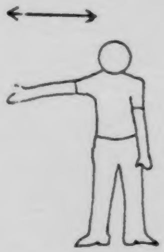
People have not always had rulers and tape measures. The early Hawaiians used the parts of their bodies to measure things.



The distance from finger tips to finger tips with arms outstretched was called an ANANA.



From finger tips of one arm to the elbow of the other arm was a MUKU.



The length of one arm was an IWILEI.

The ancient inhabitants of the land now called England also had a measuring system. The Angles used a distance measure called the ARMSTRETCH. An ARMSTRETCH was the distance between the tips of the middle fingers when the arms were stretched wide apart. This is the same as the Hawaiian ANANA.

The story could end here for younger children.

For measuring shorter distances, the Armstretch was divided into tenths. For greater distances the Armstretch was multiplied by 10, or 100, or 1,000.

(A comparison with the metric system could be made here.)

These ancient people also had small measures called the FINGERWIDTH (measured across the middle finger) and the HANDBREADTH (measured across the flat hand including the thumb). Woodsmen of early England measured lumber by ELLS. An ELL is the distance from the finger tips to the place where the ell bends. (We call that spot an elbow.) Two ELLS are equal to one half an ARMSTRETCH. You can test this for yourself if you spread your arms wide, then bend your elbows to bring your finger tips together in front of your lips. Carpenters also used the THUMB-BREADTH which was measured across the thumb at the base of the nail.

For further information on early measures see library references at end of this topic.

Get a discussion going on how you could use these early Hawaiian or early English standards for measuring the distances around (the circumferences) of the tree trunks in the school yard (or neighborhood, or at home.) If the children come up with good ideas, use theirs. If they have trouble coming up with a viable system, you might suggest those illustrated on the next page. The diagrams have been extended to full page size so that you can make copies for your overhead projector.

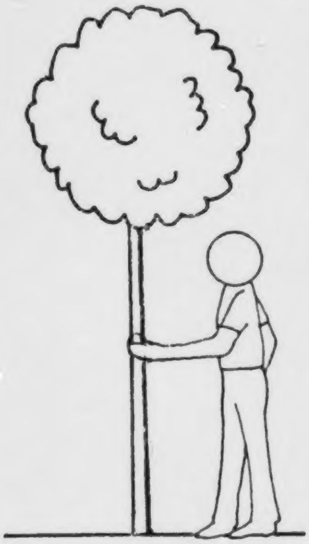
For standardizing the height at which we measure around the tree trunk, we can do what modern woodsmen do: measure the circumference of the trunk at chest height.

Either now or after they have worked awhile in the field, some frustrated students will complain about the inadequacies of this ancient measuring system. Arms are different lengths! When this occurs, it is the cue to switch from science to mathematics for awhile and discuss standards of measurements. By letting the students first bring up the problem and objection, and by seriously discussing the problem they present, an example is given that science welcomes new ideas and sustains criticism, and that "anybody" can make suggestions. If BAND 2 or 3 students reach the end of the activity and still have not posed any problem about the measuring system, you may have to initiate the complaint yourself.

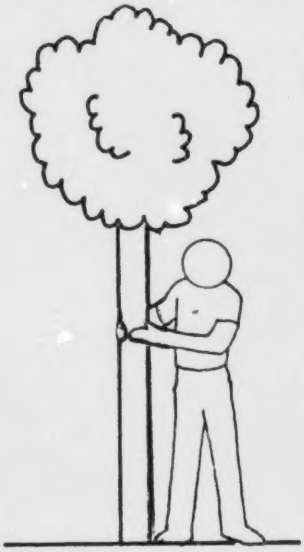
When standards for measuring tree trunks have been decided upon, assign the tree measuring and observations tasks. The assignment could be any one of the following, or another one of your own.

IDEAS FOR MEASURING TREE TRUNKS

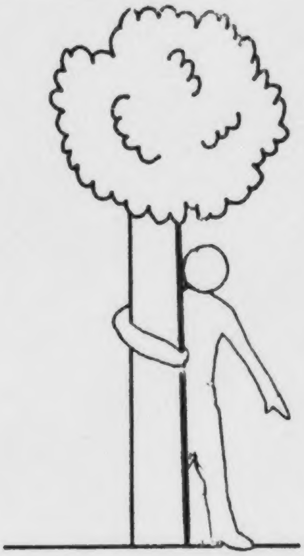
(A master copy for making a transparency or copying on blackboard.)



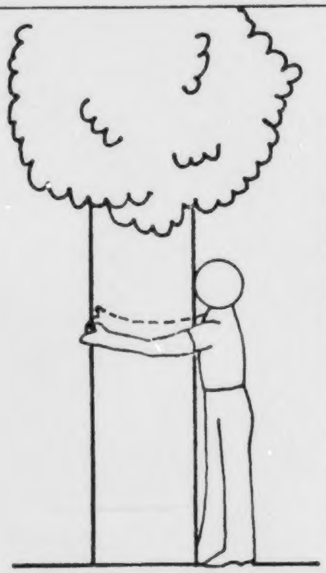
1 Hand



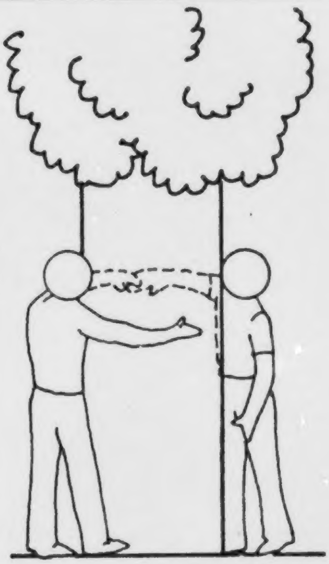
2 Hands



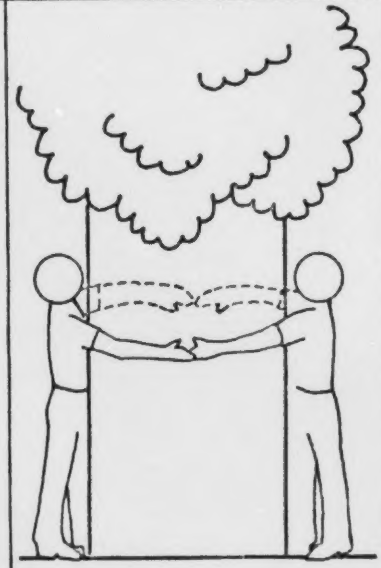
1 Arm or 1 Iwilei



2 Arms or 1 Anana



3 arms



4 Arms

a. Measure the trunks of all the trees in the school yard and notice other things about their trunks; divide the work by teams; or

b. Measure the trunks of all the trees in students' yards at home and note other characteristics of the trunk. This is individualized homework; or

c. Measure the trunks and note characteristics of all the trees which grow along __________ Street. Work in pairs or groups.

2. Next the children carry out their assignment while you circulate among them on the campus or in the area to promote hard work plus enjoyment.

3. After the measurements and the observations on trunk characteristics are complete, assemble the students back in class or in a group on the lawn. Discuss the results of their observations.

BAND 1 discussion may consist simply of a series of comments such as how "fat" or "skinny" the various trees were and something about their colors, roughness, and other observations. You might tell them that Foster Gardens has a tree so big it takes 10 people holding hands to reach around it. You might try holding hands in a circle to see how big that is. Tree trunk measuring for BAND 1 could end here.

4. If BAND 2 and BAND 3 students have not previously learned to set up data tables, keep notebooks, or make reports, Measuring Tree Trunks offers an easy introduction to all three. See the PROGRAM MANUAL for detailed suggestions and aids.

Further References:

Mattimoe, George E. and Robert Nagar. 1967. "A Brief History of Weights and Measures in Hawaii." Dept. of Agriculture Press. Honolulu, Hawaii.

Irwin, Keith Gordon. 1961. "The Romance of Weights and Measures." The Viking Press. New York.

Pilot Teacher Feedback.

One 5th grade class raised objection to the ancient measuring system before they even tried it out and went immediately to a more precise system.

Most classes went along with the historical measuring system and complained afterwards about its inadequacy. There is some value in experiencing the ancient system.

A younger class, on a subsequent class outing, ran to put their arms around every tree in the park and spontaneously turned the outing into a second session on tree measuring with discussion of the many more sizes and kinds of bark than they had seen on their campus.

2. STEMS

This topic begins the botanical work in the Parts of Plants series. Stems serve as a "skeleton" to which we can, in succeeding topics, attach each of the other types of plant structures one by one.

Stem activities continue and confirm the attitudes and skills begun in the introductory exercise, namely: The Nature Study laboratory is out-of-doors; science is a cooperative venture; it encourages original ideas from students; there are no right or wrong answers; science investigations and reports require work; and they can be fun to do.

"Stems" is spread into five sub-topics from which the teacher can select those appropriate to the class level. Those selected can be further modified to class needs.

2-A KINDS OF STEMS BAND 1.

2-B QUALITIES OF STEMS BANDS 2 AND 3.

2-C SIZES OF STEMS BANDS 2 AND 3.

2-D THE INSIDE OF STEMS BANDS 2 AND 3

2-E VASCULAR BUNDLES BAND 3

2-A KINDS OF STEMS. BAND 1

Introduction.

This exercise for very young children simply calls attention to the existence of stems and attempts to build some awareness of their differences.

Time Frame.

Probably 1 class.

Materials.

-Differently colored paper or cloth ribbons, or the equivalent, 2 or 3 per child.
-A few sample plant stems for demonstration.

Problem:

What size and kinds of stems do plants have?

Procedures-in-Brief.

Any procedure which calls attention to stems and the various stem qualities is valid. The following procedure may be helpful to you.

1. Talk about possible stem differences based on previous experience with different tree trunks.
2. Distribute ribbons to children, each color to represent a different quality to be looked for in stems.
3. Go outside. Children find stems with the quality which the color of their ribbon indicates, and tie the ribbon onto it.
4. Form student inspection teams and see if the stems selected show the quality indicated by the ribbon.

Procedures-in-Detail.

1. Recall to the children that the tree trunks (last exercise) were rough, brown, bumpy, or whatever. Could a tree trunk be considered a giant stem?

Talk about some plant stems. Ask what differences might be seen among stems.

2. Give each child 1 (or 2 or 3) ribbons of different colors. Each color will indicate a different stem quality. When they go outside they are to tie their ribbon onto a stem which goes with that color of ribbon, e.g.

   Tie a red ribbon on a ROUGH stem.
   Tie a blue ribbon on a SMOOTH stem.
   Tie a green ribbon on a GREEN stem.
   Tie a yellow ribbon on a stem which has something "funny" about it.
   Invent additional colors and characteristics suitable to the campus situation.

3. Take the class outside to look for stems on which to tie their ribbons. Give them a few minutes to get their ribbons onto the stems they select.

4. Call the class together and divide them into inspection teams (unless the class is very small). Each team goes from place to place to look at the stems selected by its members. At each stop, the "owner" points out his or her selection and tells that it was picked because it was rough, or green, or whatever. The rest of the team can confirm that this is indeed the case, and move on to inspect the next member's beribboned stem. In case of disagreement, the teacher may have to be called in.

   If interest keeps up, you could have them remove the ribbons, trade colors, and play the same game again.

   When you have obtained all the mileage you can for getting students to notice different qualities of stems, the lesson is finished. An anti-litter follow-up is to remove all the strings or ribbons and dispose of them properly.

Pilot Teacher Comments.

The ribbon system seems to work. The children are surprised to discover that not all stems are alike.

For the amusement of the students, a few word puzzles have been inserted as fillers wherever blank space was left after the text was typed. The word games are set apart from the text by a dotted border.

2-B QUALITIES OF STEMS. BANDS 2 AND 3

Introduction.

Both the BAND 2 and BAND 3 materials are joined here in the same set of procedures because the content for both BANDS is the same or similar. The difference between them is in the degree of independent action the students are capable of, and the detail and accuracy with which the students can respond. This early in the series the "planning together" between teacher and class may have a high teacher input with only a few timid ideas beginning to emerge from students. After considerable practice and encouragement, students can do most of their own planning, especially at the BAND 3 level.

Time Frame.

Probably one period with additional time for report writing which could perhaps be joined with an English class.

Materials.

-Plants in the neighborhood, especially bushes
-Notebooks

Problem:

What are the shapes, colors, and textures of stems?

Procedures in Brief.

This is one approach. You and your class, planning together, may have a different clever approach which gets the job done as well or better for your specific class and campus.

1. Plan with the class what characteristics of stems to look for and how to go about the observation and data collecting.
2. Go outside and collect data on those characteristics it was decided to observe.
3. Discuss the data.
4. Write the report (or wait and add this data to the next sub-topic on stem size.)

Procedures in Detail.

The following details cannot fit every different class precisely. These detailed procedures may give you ideas you can use in your own way.

1. Plan with the class.

Ask the class if they would agree that tree trunks (last activity) are great, big stems. (After some comparisons they usually concede that this is so.)

Review with them the kinds of things they noticed about tree trunks.

Ask if they think small plants, like bushes, flowers, weeds, and grass, have different kinds of stems, or are all stems round and brown? (This may call forth some disagreement and produce some discussion.)

No matter what opinions they hold about the qualities of stems your position is that as a scientist you cannot accept their personal opinions until you see some data or hard evidence.

Plan with the class how to get the evidence. BAND 2 students may need to be given a specific assignment to get them going. BAND 3 students may be able to figure out at least some of the planning for themselves. Try to keep size measurements out of the planning unless you are combining this topic with the next one.

Here are some sample assignments:

a. Divide into teams. Each work in a different section of the campus. Take data on color, roughness, shape, stiffness, and other qualities; or

b. Divide into teams. One team look for different colors of stems, another team look for shapes of stems, etc; or

c. Decide on a few precise qualities to be observed. Everyone individually look for and take data on these characteristics on plants growing in student yards at home.

Is there agreement to look only at bushes, or only at herbs, or at all kinds of plants?

The data sheet needs to be planned ahead of time so that everyone's columns will match and allow comparisons. Perhaps it is too soon for students to be able to set up a data sheet by themselves. One could be planned together on the blackboard.

For suggestions on how to teach the making of data tables, see the PROGRAM MANUAL. Here is a sample table for teacher's reference which has more columns than you need necessarily use.

QUALITIES OF STEMS

TABLE 1.

Stem #	Kind of Plant	Color	"Feeling" (texture)	Shape	Hardness or Stiffness	How Hard or Easy to Break	Other Special Characters
1	weed	green	smooth	round	weak	tough	--
2	bush	brown	bumpy	unevenly round	hard	snaps easily	crooked
3	coleus	green/ red	smooth	square	soft	breaks easy	lots of leaves on it
4	McCoy Grass or any sedge	green	smooth	triangular	stiff	medium	--
5	vine	green	smooth	roundish flat on 1 side	tough but bends easily	very tough	Hairs on some parts

2. Carry out the work. Collect data. The laboratory is out-of-doors.

3. Discuss the data.

This can be done by looking at one column at a time; and then comparing columns. Another way is to group plants as bushes, grass, etc. and make comparisons within each group.

Try to find correlations. Does greenness always go with softness? Are all hard stems brown? Are the hardest stems the hardest to break? Are green stems sometimes very tough?

Were all the stems round? Any unusual shapes? Did anyone find hairy stems?

4. Write up the formal, scientific report. See the PROGRAM MANUAL for teaching methods.

An alternate is write no report now but wait until stem sizes (next topic) are considered and put both topics into one report.

Pilot Teachers Comments.

Many children are amazed that stems display so many differences, especially in shape. Not all stems are round after all!

2-C SIZES OF STEMS. BANDS 2 AND 3

Introduction.

This can be used by itself or it can be combined with the last topic, using the same data table.

Time Frame.

Probably one class period for planning and collecting data plus time to discuss and write reports.

Materials.

-Plants in the school yard or home garden
-Measuring instruments of any kind the class (or teacher) decides to use
-Notebooks

Problem:

What are the sizes (diameters) of stems?

Procedures in Brief.

1. Plan with the class how to measure plant stems.
2. Go out and measure stems and record the data.
3. Discuss results.
4. Write the formal report.

Procedures in Detail.

These are step-by-step details from which you may select what is useful.

1. Plan the investigation with the class. The more planning ideas that can be pulled out of the class the better.

   Does the class remember how they measured tree trunks?
   Will that system work for measuring stem sizes?
   Shall we measure diameters or circumferences?
   How do we handle the measurement of bumpy or uneven stems?
   What measuring system can we use for stems?

If the students invent a rather awkward or inefficient measuring system, it might be a good idea to go along with it. If it gives them trouble they will soon learn the hard way to make better plans.

If the students are very young and need to have a system handed to them, here are some ideas:

a. Tie a string around the stem. Then cut the string and spread it along a ruler, preferably a metric ruler.

b. Use your mother's hemming gage from her sewing machine (with her permission!) and use it as a caliper to measure diameters of stems. It reads off directly in inches. (Can be purchased in fabric shops.)

c. To measure diameters, put a stem between two sticks and measure how far apart the stem holds the two sticks.

Who is going to collect these data? Individuals? Teams? On which parts of campus? Will each team measure all the stems in one area? Should each team have certain types of stems to measure?

Prepare a data sheet before going out to measure. One column is needed for the stem number and one column for the measurement. Every data table bears a number and a title.

If this investigation is joined to the previous one, the data table for size could simply be one more column added on to the previous data table.

2. Go outside. Measure the stems according to the agreed plan. Record the data.

3. Discussion.

As a variation from so much talking, perhaps the sizes of stems could be reported on a master data table on the blackboard by each person or team as they return from the field.

For more quiet work, the class could be asked to look at the data quietly and come to some individual conclusion about its meaning. The final conclusions could be reported.

Conclusions might be that most stems vary in size from ___ to ___; or stems are extremely variable but most of them seem to be about ___; or the sizes are variable but there seems to be some correlation between size as opposed to color and hardness. The sizes of stems seem to fall into groups: all grass stems seem to be about ___ size whereas bush stems seem mostly to be ___ size, etc.

4. The formal, scientific report follows the format described in the PROGRAM MANUAL.

2-D THE INSIDE OF STEMS. BANDS 2 AND 3

Introduction.

This activity considers the insides of stems only to the extent that these can be examined with the naked eye and with a hand lens.

The distinction between woody stems and stems having spongy, fibrous, inner tissue will be of use later when dicot and monocot plants are compared.

Time Frame.

Probably two periods, or parts of periods separated by homework.

Materials.

-Clippers, knives, saws, for getting to the inside of stems
-Hand lenses
-Notebooks

Not all the problems presented below need be used. Those for which specimens are not readily available could be deleted, likewise those which seem too difficult for the given grade level.

A difficulty which arose among many of the pilot classes in testing this topic came from choosing stems to study which were of very small diameter. Guide the students into selecting stems of sufficient diameter to show some differentiation in cross section.

Problems:

1. Examine the inside of stems of grasses and small green weeds. Report on how these stems are alike and how they differ from one another.

2. Saw across a tree branch which is at least 3 or 4 cm in diameter. Discribe what you see in the cross section. (Parents may be able to help choose a tree branch which needs pruning anyway.)

3. Cut a section through 1 or 2 large hard branches and through several new green stems of the same shrub or tree. What likenesses and differences do you find within these different stems of the same plant?

4. Find a banana plant which can be cut down or a banana stump which has recently been cut. Describe or explain what you see in the cross section. (This problem will recurr in the next topic.)

5. Obtain a bamboo stick with several sections to it. Open the bamboo lengthwise and describe what you see.

6. Examine the inside of stems which lead up to the flowers of dandelion, calla lily, amaryllis, or a flower whose leaves are grass-like. What is inside these stems?

7. Try to break off by hand some of the following branches: oleander, hau, ginger, poinsettia, allamanda, or any vine. What troubles do you encounter in doing this and what causes the trouble? How are the inside parts of the stem arranged? (Teachers note: substitute or add any campus plants which have tough bands of tissue difficult to break.)

8. How many plants can you find in your neighborhood which bleed milky juice when the stem is cut or broken? Do all parts of the plant bleed? How long does the bleeding continue? What changes take place in the milk after it comes out of the stem? How hard or easily does it wash off your fingers? Does it stain cloth?

9. Make a collection of stems which have an odor or fragrance when cut or broken. Can you tell which stem is which by the smell? Make a list of stems and smells.

   WARNING: Oleander sap is extremely poisonous.

Procedures in Brief.

1. List one, several, or all the problems for students to consider. With student help, decide who will do which problems, or whether everyone will work together on only one or two problems.

2. Students pursue their investigations.

3. Student reports. Teach some technical vocabulary.

4. Students write up their reports, either formal or informal type.

Procedures in Detail.

1. List the problems for the students on the blackboard or make ditto copies for them. Delete, add, and change problems to suit your campus and neighborhood.

   Problems could be volunteered for, apportioned by student decision, or be teacher assigned.

   Students might work alone, in pairs, in groups, or you may prefer to have the entire class work together on only one or two of the problems.

   It is up to the students to plan what instruments to use to get inside the stem, what observations to make, how to record the observations, and prepare their reports. Very young students may still need some help with this.

2. The students could pursue their problems during class time on campus, or as homework, perhaps as several days or weekend homework.

3. Students report their observations and results to the class using diagrams or examples.

Reporting time is also time for learning some of the technical vocabulary associated with the structures the students observed. See terms given in the Teacher's Background Information at the end of this topic.

There are a number of ways to introduce new terms. Here are a few ways:

a. After each student or group of students have reported their observations, compliment them on their careful observation and then explain the vocabulary which goes with what they have described. They can add these terms into their written reports.

b. Meet with the investigators individually before they present their class reports. Teach them the terms which apply to their observations. The students can then report to the class using the proper terms and simultaneously teach the terms to the class.

c. Wait until all reports are finished. Then give a lesson on pertinent stem vocabulary. Let them add these new words into their reports.

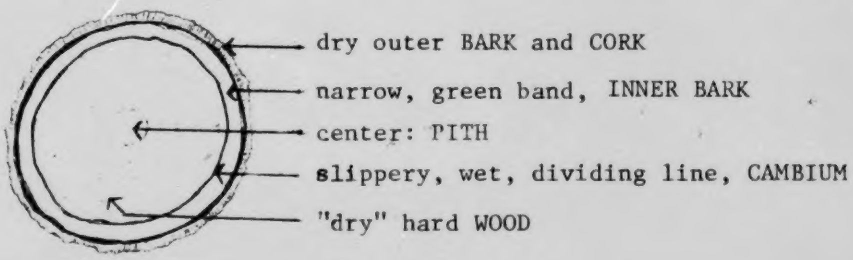
4. The Reports.

The oral reports could be accepted as sufficient; or
Each student might make a formal report of his own problem and investigation; or
Informal notebook reports might be recorded from notes taken in class on all the problems as reported by the students in turn.

Teacher Background Information.

The internal structure of stems is far more complex than can be observed with a hand lens. The rough sketches below indicate about as much as the students can see. (Information given in parenthesis is visible only under the microscope and is for the teacher's information only.) Even the few terms not in parenthesis need not necessarily all be taught.

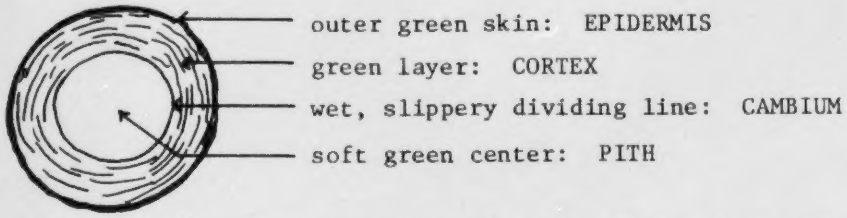
1. Woody stems, such as tree trunks, tree and shrub branches more than one year old.


dry outer BARK and CORK
narrow, green band, INNER BARK
center: PITH
slippery, wet, dividing line, CAMBIUM
"dry" hard WOOD

The cambium is too narrow to see the structure with the naked eye and seems simply to be a slippery dividing line between the wood and the cortex. (The cambium is a cylinder of vascular tissue. The cambium is the center of growth and cell proliferation consisting chiefly of phloem and xylem cells which are the water and sap carriers. Hence the wet slipperiness.)

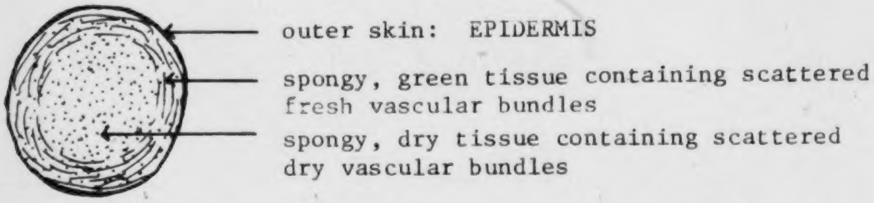
Wood in temperate zone trees shows annual rings, one for each burst of new spring growth. Tropical wood grows fairly evenly all year round and so lacks rings. (Wood is secondary xylem tissue.)

2. Green, non-woody stems (herbaceous dicots) such as most weeds, most garden flowers, and the new green growth at the ends of shrub and tree branches.


outer green skin: EPIDERMIS
green layer: CORTEX
wet, slippery dividing line: CAMBIUM
soft green center: PITH

(Beginning with the second year of growth, the cambium lays down secondary xylem or wood which thickens year by year and occupies the area between the cambium and the pith.)

3. Green, non-woody stems (herbaceous monocots) such as grass, lily, sugar cane, corn, pandanus, coconut trunk, ti. (The older monocots lose their greenness.)


outer skin: EPIDERMIS
spongy, green tissue containing scattered fresh vascular bundles
spongy, dry tissue containing scattered dry vascular bundles

(There is no cambium of the "slippery dividing line" type. New vascular bundles are scattered between the ground parenchyma cells forming a green cylinder below the epidermis. As these are pushed in toward the center they become dry and hard. New ground tissue interspersed with new vascular bundles forms a cylinder around the older tissue.)

In grasses, the center sometimes becomes hollow except at the nodes.

In coconut trunk, ti, and pandanus, the center fibers become very strong and brown but they are not wood. (They are not secondary xylem.)

In sugar cane the center tissues remain "wet" and store sugar.

4. Other Comments.

A papaya trunk is a hollow, non-woody stem (herbaceous dicot).

The stems (peduncles) leading up to some flowers such as dandelion, lily, amaryllis, are hollow.

The banana plant is not a tree (it is a herbaceous monocot). The "trunk" consists of concentric wrapping of the leaf bases. . .same structure as an onion. The only true stem in a banana plant is the one which supports the fruit.

"Milk" in stems is latex carried in its own network of tubules and ducts (laticifers). Latex, while carried in ducts within the plant, is not mixed with the plant sap. The latex in oleander contains lethally poisonous alkaloids. Slightly poisonous alkaloids are in the latex of plumeria and some other milky plants. The milky resin in mango is non-poisonous but produces an allergic reaction in some people. The latex of certain South American species is harvested to make chewing gum and rubber. (Latex is a suspension.) Latex tends to "gum up" and get sticky when exposed to the air as the water content evaporates.

The fragrance in various woods are due to the presence of different kinds of "essenses" or essential oils enclosed in minute sacs within the stem or other tissues of the plant. These oils, especially when the sacs are broken open, give the familiar odors to camphor wood, cedar wood, sandalwood, eucalyptus, cinnamon bark and other spices, fragrant flowers, citrus rinds, and other fragrant members of the plant world.

BAND 1 Puzzle

Directions: Select a vowel (a,e,i,o,u) to place in each blank. The completed words are plants or parts of plants.

F R __ __ T

L __ __ F

F L __ W __ R

B __ D

R __ __ T

P L __ N T

S T __ M

B __ S H

T R __ __

T R __ N K

S __ __ D

B __ L B

L __ __ V __ S

N __ D __

B R __ N C H

2-E VASCULAR BUNDLES. BAND 3

Introduction.

This experiment is designed for upper elementary students with at least some science background and experience.

Besides teaching the presence of vascular bundles, this lesson gives students practice in the important scientific technique of inventing and using analogies. The value of learning the skill of model-making can alone justify the several periods of class time this investigation takes.

Time Frame.

Possibly 2 to 5 class periods.

Informational Background for the Teachers.

Plant stems contain vascular bundles which transport water and foods from one part of a plant to another part. A large proportion of the transport is concerned with transpiration, i.e. the movement of water from roots through vascular bundles to the leaves and out through the stomates to the air.

Vascular bundles are complex systems of hollow cells of different kinds interconnected in an elaborate maze. In a living and actively transpiring plant, tiny columns of water move up through the vascular conduits by pressure differential maintained between the cells; and in a state of tension maintained by the cohesion of water molecules.

When a stem with intact water columns is severed from the plant and carefully set up as illustrated in the procedures it can continue to conduct water in the manner of a siphon. A siphon is set up as a model for studying this one phase of behavior in a plant stem. In both a siphon and a stem, water flows through the tubes from a higher to a lower water level over an intermediate elevated section. In both the siphon and the stem the tubes must be filled with water in an unbroken column for the water to flow. Any discontinuity in the water column, such as an air bubble, blocks the flow.

A glass capillary tube is used as the siphon because: 1. the size of the capillary slows down the siphoning to a drip, giving resemblance to the drip from a severed stem; 2. the glass walls of the capillary allow the students to observe water movement and the effect of air blocks in the column. From the glass capillary the students can then make comparisons and draw inferences about the possible structures and hidden action in the opaque stem.

The siphon, like all models, has its limitations. It does not demonstrate all the actions of which the vascular bundles are capable. The vascular columns in a coconut tree for example, conduct water from below ground level straight up 100 feet or higher and then out into the air. No siphon can do that. Despite its limitations, the siphon model is useful in that it allows the students to infer that some kind of water conducting system must be inside a stem. It is also useful because it is a simple, clear example to the students of what a model is and how a model can be used in science to infer things by analogy.

In this lesson, the procedures call for coleus or tomato as the experimental plants. Since all vascular plants have water-conducting vascular bundles, it should be possible, theoretically, to turn any stem into a siphon. For reasons which are far from clear, some stems make better siphons than others and some refuse to siphon at all. Two reliable "drippers" are the youngest, fresh, green shoots and the green petioles (leaf stems) of both coleus and tomato. After the students have succeeded in siphoning with the tomato and coleus, they may use their skills to try the more difficult stems and other conditions of transport.

Be careful not to employ a hollow stem, such as the petiole of papaya or the flower stalks of dandelion, lily, or amaryllis. Water runs through these hollow centers in the same way as through a garden hose. The plant stems used in this experiment are not hollow; they are "solid" tissue.

Materials.

- *Coleus and tomato plants.*
- *Baby-food jars or similar glass containers, 2 per student or per team.*
- *Jar lids, any size, or saucers to catch drips of water, 2 per student or team.*
- *Short, curved capillary tubes, 1 tube per student or team. A package of 100 tubes costs $1.20. For obtaining and preparing, see below.*
- *Large, flat pans of water, 2 or 3 per class.*
- *Razor blades or very sharp knives, 2 or 3 per class. These last two items are for cutting plant stems under water.*
- *Wire, easily bent but stiff enough to hold its shape, about 6" per student or team.*
- *1 roll wax paper for class use.*
- *Ball of thread or plant ties for class use.*
- *Newspapers and rags for caring for water spills.*
- *Notebooks.*

Procedures in Brief.

This set of procedures looks first at a demonstration dripping plant stem; then sets up the siphon model. Another approach would be to study siphons first and then introduce the dripping plant stem.

1. Set up several working demonstrations of a tomato or coleus stem. See diagrams under detailed procedures below. Allow several hours observation.

   Challenge students to explain the dripping from the stems and to think of some analogies to this behavior. Explain what a model is and how and why a model is useful in science.

2. Let them play with the model of glass capillary siphons and investigate conditions of siphon operation.

3. Students set up parallel sets of a glass tube siphon and a dripping stem and list likenesses and differences between the flow of water in the stem and in the glass model.

4. Help students draw the inferences from the siphon to the stem, chiefly that their similar behavior would indicate that the opaque and seemingly solid stem must contain some kind of structure which is the equivalent of a capillary tube siphon.

5. Teach the term Vascular Bundle. Discuss the values and limitations of learning from models.

6. Notebook report.

7. (optional) See listed challenges for trying other stems and other conditions.

Procedures in Detail.

The details given here cannot possibly match every situation which develops in every classroom. These details give ideas for one feasible approach and fore-warnings of only some of the "discoveries" and conundrums which may surface.

Note that Procedures 1 and 2 both require preliminary laboratory preparation by the teacher.

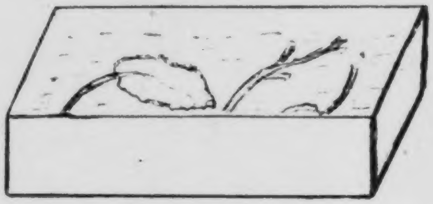
1. The working demonstrations of dripping stems.

Teacher preparation before class:

Obtain a fresh, living plant of young tomato or coleus. Have the plant well watered and not in wilt. With a sharp razor, remove a young section of green stem, cutting it off on the slant, and submerge it immediately in water in a large pan. Also remove a few large leaf stems by cutting on a slant close to the main stalk. Submerge these also in the pan of water. Leave these submerged while you prepare the wires.

Bend several wires, of about the same length as the stems, into U-shapes. Keep the U broad enough so the stem will not break when it is bent to the same shape.

These illustrations are highly diagrammatic. For clarity they show only one water column in the stem whereas vascular bundles are multiple.



Pan of water with submerged cut stems and petioles.

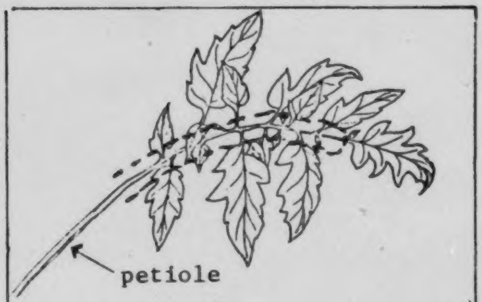
Working under water, remove all the leaf blades. If the petiole is short, it can be "lengthened" by cutting away the sides of the blade and retaining the midrib of the leaf as an extension of the petiole. Coleus and tomato have water pores (hydathodes) at their leaf tips so they will drip water through the leaf tips even if the whole leaf is kept intact. But the presence of the leaf obscures the idea that the stem is the conducting tube so the analogy is clearer if the leaf is removed.

Still working under water as far as possible (It is not always possible.) fasten the stem to the wire by winding both together with thread, or using plant ties, or any feasible means. Avoid using thick, soft string or a material which would act as a wick and conduct water along the outside of the stem. Stems with a natural curve need not be wired.

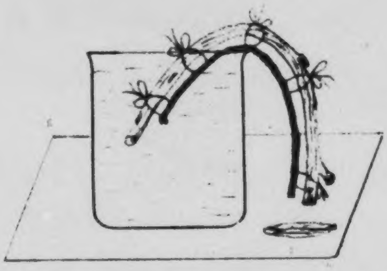
Fill several small jars with water to the brim. Balance one of the wired, curved stems in each of the jars so that one end of the stem is in the water and the other end is directed downward, hanging free in the air outside the jar. Put the outside end of the stem as low as possible below the water level to increase the speed of the drip.

With a soft cloth, pat the stems dry and wipe the outside of the jar to preclude the idea that dripping may be coming from the outside of the stem.

With even mediocre luck, most of the stems will begin dripping within a few minutes and can keep going for days. The drip slows and then stops as the water level falls to the level of the outside stem tip. Refill the jar with water and thus restore the faster drip.



Petiole of a tomato leaf made "longer" by cutting away sides of leaf (dotted lines) and allowing the leaf midrib to act as an extension of the leaf stem.



Tomato or coleus stem tied to a U-shaped wire and balanced over the edge of a glass of water. Outer end of stem is down as low as possible without touching table. Wax paper on table shows water drops.

Method for Cutting Stems

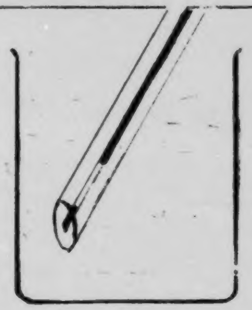
When stem is cut in air, water column under tension recoils into stem and draws in air.

Later in the experiment, the students will have less luck in getting their stems to drip because they work slowly with stems out of water so that the stems acquire air locks. When this happens, the following information will be of assistance in helping them through the difficulty.

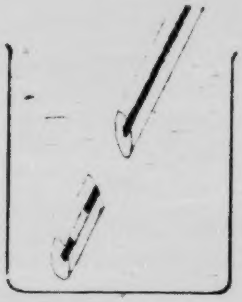
An actively growing plant has a continuous unbroken water column in its vascular bundles. The water column is under tension like a stretched rubber band by the cohesion of water molecules. When the stem is cut, the water column recoils away from the cut into the stem, drawing an air bubble into the stem at the end of the column. Later when the stem is placed in water, the water enters at the cut and the air is trapped, breaking the column of water with an "air lock". Water cannot move up the column until the air is gotten out.

An air lock can be removed from a living and transpiring stem by submerging the stem in water for a time; or by recutting the stem under water far enough up to remove the portion containing the air bubble.

The diagrams supplied here can be made into overhead transparencies for use in instructing the class in these techniques, if and as the need arises.



The stem which had been cut in air is placed in water. Water enters stem from bottom cut but an air lock is in the column. If left in water long enough, and if stem is alive and active, air bubble will gradually be worked out.



Faster way to remove air lock is to recut stem while stem is submerged in water. When cut is made under water, water is drawn into stem as column recoils.

Set your demonstration jars of dripping stems on dry wax paper in easily observed locations around the classroom. The wax paper readily shows any drops of water which fall. For excessive dripping, place a lid or saucer under the dripping tip.

Let the class observe your working demonstrations for a couple of hours or longer. If the stations are set strategically around the room, the students can watch in between doing their other lessons.

Beginning of Class:

After the students have observed the dripping for some time, begin the science class by asking what seems to be happening. Do the students have an explanation for the drip?

Can they think of any mechanical device which behaves the same way? With luck, they might think of a siphon, such as is used in the class fish tank. If they do not think of a siphon, you may have to hint until they do.

Explain what a model is: i.e. a mechanical device which imitates some aspect of a living or "real" thing. Examples of models are clothes manikins (both plaster and living kinds) and model cars and trucks. Before the astronauts went into space they tested their reaction to weightlessness in a simulator or model of the "real" circumstances. Airplane designers make models of planes to test in windtunnels so they can measure structural strength and design.

Models give us an idea about the use or functioning of some other object or situation, especially when we cannot test the second object directly. We can do experiments on the models and make applications to the "real" objects.

From what they have seen so far of the dripping stems, and from what they have generally observed about fish tank siphons, does the class think the siphon may possibly be a model of the dripping leaf? Granted there are differences between the fish tank siphon and the leaf, but are there some similarities that can be compared?

If the class accepts that the siphon may possibly be a model for the stem, the next step is to find out everything possible about the operation of the siphon. After that the dripping leaf can be looked into further and the two systems compared.

2. Investigation of a siphon.

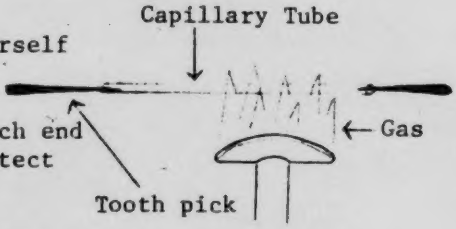
Teacher Preparation before Class:

Obtain and prepare capillary U-tubes.

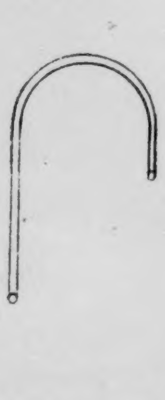
One source of capillary tubes is Hawaii Chemical Co., 2363 N. King St. (near Middle Street), 96819. They come 100 tubes in a bundle for $1.20 per bundle. Each tube is 100 ml long. The order number is Kimax 51 Capillary Tubes #34500. One bundle should last for several classes.

Before class, bend the tubes, either yourself or with the help of some youngsters.

Place a tooth pick (or equivalent) in each end of a tube to serve as handles and to protect fingers from hot glass.



Hold the tube, somewhat off-center, inside a blue gas flame for about a minute. As the glass reaches fusion temperature, bend it into a U-shape with one arm of the U longer than the other. The unequal arms allow greater flexibility in trying various tests.



Do not make the bend so sharp it constricts the tube. After you ruin the first few tubes, successful bends may be made quite easily.

Beginning of Class:

Give one U-shaped capillary tube to each working group. Each group also needs a small jar or glass of water and a lid for catching water drops.

How much can the students find out for themselves about the operation of this glass siphon? Give time to investigate. They usually want to play with their little siphons for a whole class period.

During conversations as you circulate through the room, you may be able to solicit verbalization of results. Discoveries might be listed one by one on the blackboard. If all discoveries are received with equal acceptance and listed with equal emphasis students gain courage to voice ideas they are unsure of.

When the following "discoveries" or their equivalent appear somewhere in the list the students have enough information to proceed with the investigation:

-The tube has to be full of water to get the siphon to work.
-The outside end of the tube has to be below the water level in the jar.
-If you lift the tube entirely out of the water, the drip will not start by itself when you replace the tube in the water. It has to be filled up with water again first.
-When an air bubble is in the tube, no water flows and the drip will not come.

Among their "discoveries" they may have listed other important items which are not followed up in this lesson, such as:

-The water will go up in the tube a little way by itself.(capillarity)
-The closer together in height of the water level and the outside tip of the tube, the slower the drip comes. (depth and pressure problem)
-If you put one end of the tube in one jar of water and the other end of the same tube in another jar of water you can get the water to flow through the tube in either direction by lifting or lowering the two jars. (gravity flow)

The students may become involved in siphons and want to go on to flexible hose siphons, using syringes to fill siphons, setting up tandem or series of siphons, and so on. Whether you want to branch off here into a lesson on gravity flow, capillarity, cohesion of molecules, pressure of water of varying depths, is up to you. It makes a good lesson in physics.

3. Comparing the Model and the Prototype:

Each student group has previously observed the teachers dripping stem from afar, and has now experimented with the operation of a siphon. Next the students need to make a careful comparison between the dripping stem and the chosen model.

Each group needs its own dripping stem, set up in the same size jar as the glass siphon and placed next to it so that comparison can be made.

The students should set up their own stems rather than "hi-jack" the teachers demonstration exhibits because of the experience students gain by handling the stems themselves and learning how to free them from air bubbles.

Have a supply of jars, plants, wire, etc. in a central location.

Below are two styles for putting the students to work on dripping stems:

STYLE 1.

Style 1 is for inventive students whose teachers have lots of plants and lots of patience.

Tell the students to go to work and prepare dripping stems. Give no help or hints about working under water or any other advice. They have your earlier demonstration as an example of the completed product.

Coleus and tomato stems are so hardy the studentsmay actually get some stems to drip despite abuse and exposure to air.

If some stems fail to drip, ask why. See if they can make the comparison between the need for eliminating air bubbles in the siphon and the possibility of air bubbles in the stem. Can they think of a way to rid the stem of air bubbles?

As a last resort, give the students some instruction on how to work under water and why.

STYLE 2.

Style 2 is a teacher-directed step-by-step process which gets the job done quickly and properly on the first try.

Discuss with the class what actions of the siphon they need to remember as they fix their stems.

(Ans: The siphons needed a continuous column of water with no air bubbles.)

Show them how to cut stems under water so that no air bubbles are admitted to the stem, using the diagrams and directions from the teachers notes above in #1 to help explain.

With this preliminary instruction, the students should be able to set up some dripping stems.

Eventually, either by Style 1 or 2, each working team will have in operation before it, two jars, one with a dripping capillary tube siphon, and one with a dripping plant stem.

List likenesses and differences between the capillary siphon and the plant stem.

The blackboard or overhead may serve as a report sheet; or each group may work out its own lists quietly.

Likenessess they may find:

-The dripping tip has to be lower than the top of the water in both the siphon and the leaf.

-The lower the tip compared to the height of the water, the faster the drip in both cases.

-When enough water drips out to bring the top of the water down to the level of the tip of the stem or the tube end, the drip gradually slows and then stops.

They may notice other likenesses but the above would be sufficient.

Differences they may find:

-You can't see the water going through the opaque stem but you can see water going through the transparent glass tube.

-You can see that the siphon does not drip when the water column is broken by air, but you can't see what it is that makes the stem stop dripping.

-The stem drip is slower than the siphon drip.

-The stem is green and soft. The glass is hard, stiff, and transparent.

-The stem is a living thing (or is it?); but the glass is not alive.

4. Draw the inference from the model to the stem.

Notice that the likenesses which have been listed are mostly similarities in behavior or action in moving water. There is little likeness between color, hardness, growth potential, etc. between the siphon and the stem.

Can the class agree that the siphon is a model of the stem for the action of carrying water; but that it is not a model of the stem for lots of other things?

Since the two systems behave similarly, can we assume that the stem (of which we cannot see the inside) may contain some kind of structure which allows the stem to behave similar to the siphon? Note that we are not saying that the stem contains a glass tube. We are saying it has a structure which allows it to behave like a tube.

When this agreement is reached, it can be called a theory or conclusion. When scientists come to a conclusion based on a model, they accept the conclusion as workable and dependable until somebody comes along with a better model or with evidence that the model is not correct, or that the conclusion is not correct.

Have the students write in their own words their conclusions or working theory about the stem, based on what they drew by analogy from the model.

5. What science has to say about the inside of stems:

The following is a teacher presentation of information which serves as a substitute for checking on the stem by microscopic pursuit. It may be relayed to the class by any method you desire. Below is a sample lecture which you may use or modify as you wish. (Any school equipped with sufficient microscopes, microtomes, and a teacher who knows microtechnique could do a microscopic laboratory investigation on internal stem structure rather than depend on the following type of lecture.)

Sample lecture:

Botanists also have noticed that stems act like siphons and conduct liquids. With microscopes they have examined the inside of stems and found bunches of very tiny threads and chains made up of hollow cells joined together. They have called these bunches of hollow threads VASCULAR BUNDLES.

Vascular bundles are arranged in a row all around the inside of the stem. In the last experiment, the wet, slippery dividing line between the green cortex and the dry wood, was the circle of vascular bundles along with active growing tissue called the cambium. (See diagrams in last sub-topic.) The cells are too small to see with the hand lens but they move so much water and plant sap you can feel the wet slipperiness.

Do you notice that even though we used no microscopes, there was a lot we could learn about stems and how they act by working from a model? Scientists often work with models when they want to study something they can't get at directly. It will be worth while to keep this model idea in mind for problems we get into in the future in which we cannot work directly with the actual objects.

Now that you have learned the name, vascular bundle, you may wish to revise or add to the conclusion you wrote down a little while ago.

6. The investigation can end here and the report be written up. The format is given in the PROGRAM MANUAL.

Title
Statement of Problem
Procedure (use of model)
Data (with diagrams and descriptions of the dripping action)
Discussion
Conclusion

From here you may go on to some of the challenges below; or you may consider that this is enough time and labor for the subject of stems and go from here to Topic 3 on the Plant as a Whole.

Additional Investigations.

The following may be duplicated and pasted onto file cards for use as individual challenges.

1. Can you get the stem of a plant other than coleus or tomato to drip?	If you come across any good ones, please report so we can add them for use in the next edition.
2. Can you get an older or thicker stem to drip?	Usually not.
3. Can you get water to run through the stem in the reverse direction, i.e. put the leaf end in the water and let the lower end of the stem hang outside the jar?	Yes.
4. How long can you keep the same stem dripping? Hours? Days? Weeks? What eventually stops it?	Days. Possibly more than a week. Deterioration of the stem tissue.
5. Set up a dripping stem. Add deeply colored water to the jar. How long does it take the colored water to come through the stem?	Depends on how fast it drips.
6. Thoroughly wet a short piece of woolen yarn. Hang one end of the wet yarn inside a jar of water, touching the water. Hang the other end over the outside of the jar. Is this another model of a stem? How and how not? Why or why not?	The wool serves as a wick.

3. THE PLANT AS A WHOLE BANDS 2, 3

Introduction.

In this topic, students are asked to "step back" as it were, and view the plant as a whole, noting general overall shapes and differences; then noticing the various kinds of structures attached to the basic plant skeleton.

Logically, this topic belongs first in the study of Parts of Plants. But psychologically in the teaching strategy, it works better if a simple content activity (e.g. tree trunks and stems) is taken first.

Time Frame.

Probably one period.

Materials.

-Whatever trees, shrubs, and herbaceous plants occur in the school yard and neighborhood, at least some of which are preferably in flower and bearing fruit.

Problem:

What different sizes and shapes do plants have?

What different kinds of structures make up a plant?

Procedures in Brief.

There must be as many ways to handle this organizational topic as there are teachers. These procedures show only one way which you may find convenient to use until you have had time to develop a teaching plan of your own.

1. Take the class outside. Look at plants as a whole. Distinguish between trees, shrubs, and herbs.
2. Note that stems are the framework or skeleton of plants.
3. Make sketches of plants with the aim of noting what kinds of things are attached to the stems.
4. Discuss what kinds of parts plants have (leaves, roots, flowers, fruits, seeds) and lay out a plan to investigate each in turn.

Procedures in Detail.

1. Distinguish between trees, shrubs, herbs, vines.

Find a place on campus to sit together in sight of at least one tree, one shrub, and one herbaceous plant.

Stir up some discussion about the overall form, or shape, or distinction, or means of identifying, the general categories of plant growth visible on all sides.

Trees and Shrubs:

What do you call that kind of plant? A tree? Why is it a tree?
What do you call that plant over there? (shrub--bush)
Why don't you call it a tree? What is the difference between it and a tree?
Could it grow bigger and become a tree?
Is a very small tree a tree, or does it have to grow big to be a tree?
What is a tree?
What is a shrub?

When the class comes to some consensus concerning what constitutes a tree and a shrub, have them write their agreed-upon definitions into their notebooks. Their definitions should include the idea of a woody trunk for trees, and multiple woody stems for shrubs.

(English lesson: You cannot define an object by saying, for example, "A tree is when . . ." "When" cannot follow "is". Also, the definition should include the general characteristics of many trees; it should not describe one tree.)

Herbaceous Plants or Herbs:

Tell the students that botanists give the name HERBACEOUS PLANT or HERB to plants which have NO woody stems and never will have woody stems. Mention that many spices are herbs, but not all herbs are spices. Any non-woody plant is a herb.

Ask if they see any examples of herbs from where they sit (grass, weeds . . .). The green tips of tree and shrub branches do not count as herbs because these will become woody when they are older. The green branch ends are part of a woody plant.

The next entry in the notebook is the definition of a herb which should include the idea of total non-woodiness.

Vines:

What is a vine?
Their definition needs to include at least that it is a climber.

Vine stems can be either woody or non-woody, depending on species. Another name for vine is LIANE, or LIANA.

Game:

Point to different plants in line of sight and let students respond "tree", "shrub", "herb", or "vine", as the case may be. (Note: long creeping grass stolons are not vines. They do not climb.)

"Tricky" plants:

Banana is herbaceous. All its parts are green and non-woody. The "trunk" is not a tree trunk but an overlapping of many leaves. Its only stem is the one which supports a bunch of bananas.

Sugar cane, bamboo, and corn are herbaceous. In fact they are grasses.

Papaya trunks are hollow and non-woody but by custom we call them trees anyway.

The Hau tree has a trunk which is so gnarled and twisted it sometimes looks like a giant vine but it has the wood structure of a tree trunk.

2. Stems form the framework or skeleton of plants.

Ask the students to imagine what shape a tree (shrub, herb, vine) would have if it had only leaves,
. . . only flowers,
. . . only fruits,
. . . only stems.

Which of those parts gives the shape to the plant?

This can lead to the conclusion that stems are the framework or skeleton.

How many different words do you know for stem?
(stick, branch, trunk, stalk, twig, switch, cutting, slip)

3. The parts attached to stems.

Assignment: Given a plant skeleton, show on a sketch the different kinds of things which are attached to the skeleton to make up a whole plant. (Artists make pictures. Scientists sketch or draw what they see.)

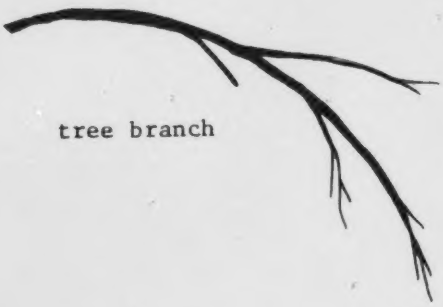
Outlines for different types of plant skeletons are shown at the bottom of page 34. These may be reproduced on the blackboard or shown on the overhead to give students an idea of kinds of plant skeletons from which to begin their sketching. BAND 3 students may be urged to begin from a blank page and design their own basic plant skeleton to which to add attachments.

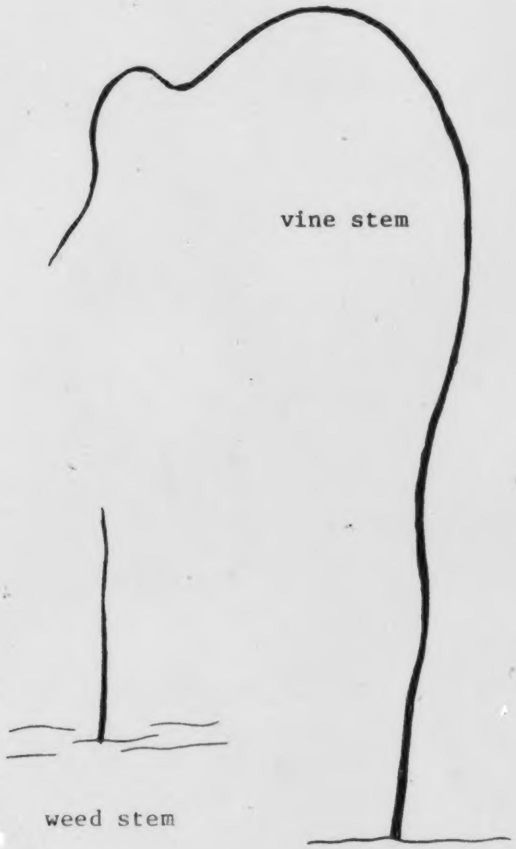
Students may sketch one plant of each type, or perhaps only one plant of any of the suggested types. Some students may be interested in taking only a small section of one branch, observing it very carefully with a hand lens, and sketching all its parts and attachments in precise detail.

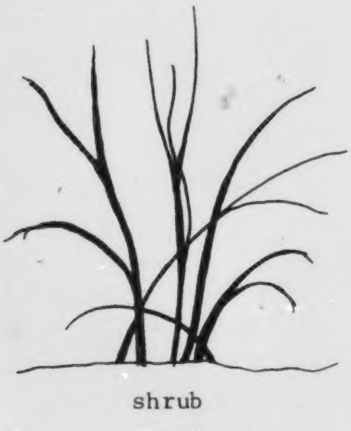
4. The parts which plants have.

From the completed student drawings, identify at least stems, leaves, roots, flowers, fruits, seeds, plus whatever else they have put into the drawings. How many remembered roots? Roots are attached to stems, too.

Tell the students these parts they have identified will become the headings of the topics to be studied one by one.







4. LEAVES

Green leaves are the basic life support system for all life on earth. In proportion to their importance, their structures and shapes are simple. Yet viewed one by one they present a great variety of form and provide an endless source of study and inspiration for collectors and artists as well as scientists.

This topic considers the gross external structure and characteristics of leaves in the school and home neighborhood. Work with leaves prepares students for later work in recognition, classification, and identification of plants, as well as for the later study of leaf functions and their important role in the ecosystem.

The chief skill practiced in this section is observation.

The technical vocabulary included under "leaves" is extensive. Not all of it need be given to the students. Teachers are encouraged to expose the students to a reasonable amount of technical vocabulary by writing the words on the board for the students to see and pronounce, and by using the words themselves. Children pick up new words quite readily in an informal way and are often proud of extending their vocabulary. At this level there is no need to make vocabulary into a memory burden.

"Leaves" is divided into 6 sub-topics:

4-A LOOKING AT LEAVES. Band 1

4-B LEAVES, SIMPLE AND COMPOUND. Bands 2 and 3

4-C LEAF COLORS, TEXTURES, SHAPES. Bands 2 and 3.

4-D LEAF VEINS. Bands 2 and 3

4-E LEAF ARRANGEMENT ON THE STEM. Bands 2 and 3

4-F LEAVES, SPECIAL CASES. Bands 2 and 3

4-A LOOKING AT LEAVES. Band 1

Introduction.

Primary children need to become acquainted with the external features of leaves to gain awareness and appreciation of their variety and interesting qualities.

Time Frame.

Probably 1 or 2 of the listed problems could be done in one class period. Some of the other problems listed below could be done in other periods for as long as interest lasts.

Materials.

-Leaves from the campus, home, neighborhood.

Procedures.

A number of "mini-problems" are listed below for Band 1 level consideration. The general procedure for each mini-activity is:

1. Collect leaves on campus or bring from home.
2. Look at the qualities or carry out the tasks indicated for leaves.
3. Talk about and enjoy the leaves. Make sketches.

The list of "problems" given here are not sequenced; and can be selected from, or added to, as desired. For additional action, a primary teacher may wish to scan the topics written for older students (Sub-topics 4-B to 4-F) and extract any appropriate ideas which could be modified for Band 1 use.

Band 1 "Problems" on Leaves.

Leaf sizes:

Who can find the biggest leaf? the smallest?
What size (about) are most of the leaves in our school yard?
Are all the leaves on any one plant the same size?

Leaf Shapes:

Did you ever see a round leaf, or one almost round? a nearly triangular leaf? a long, skinny leaf? a thick, fat leaf? Look for leaves of different shapes and bring them to school.

Use leaves (without their stems) as if they were pieces of a jig-saw puzzle and see if and how they can be fitted together.

Leaf Tips and Margins:

Look at the tip ends of leaves.
Line up many leaves in a row. Put the leaf with the most pointed tip at one end of the row and the least pointed tip at the other end.
Can you find leaves which have an edge which a menehune could use as a knife, a comb, a saw, a pin point?

Leaf Texture:

Close your eyes and hold a leaf. How does it feel?
Do all leaves feel alike?
What are some of the different "feels" among different leaves?

The teacher, or a group of students, may put leaves of different textures in a paper bag along with some similarly textured and shaped articles such as pieces of felt, paper towel, wax paper, etc. Children may take turns putting their hands in the bag and guessing what they have, before pulling it out. (Some good leaf textures to include are sandpaper vine, hairy merremia, velvety clerodendron, waxy philodendron, thick-leaved succulents.)

Leaf Veins:

Do you see the ridges and lines in leaves? They are called VEINS.
Are all veins the same size?
Are they the same on the top and bottom surfaces of the leaf?
What pattern or design do the veins make in the leaf?
Are the veins the same color as the rest of the leaf?

(See sub-topic 4-D for slitting leaves with pins to determine the direction of venation.)

Leaf Colors:

"Paint" a picture, or make a mural, or a mosaic, by cutting up and fitting together leaves and parts of leaves of different colors.

Can you build a rainbow out of colored leaves?

Special Leaves:

Sub-topic 4-E on Sensitive Plant could be adapted for primary children.

"Looking at Leaves" may be considered successful and complete for Band 1 when the children have noticed and taken delight in many kinds of leaves and leaf qualities.

4-B LEAVES, SIMPLE AND COMPOUND. Bands 2 and 3

Introduction.

The ability to distinguish between a simple and a compound leaf is basic to the understanding of other leaf observations. More detail is given here than need necessarily be taught to the students.

Time Frame.

Time allotment is difficult for this topic which involves making many brief observations. You may wish to cut down on the number of items to observe so that the topic will fit into one class period. An alternative is to spread things out, using a few minutes per day; for example, do preliminary vocabulary in a short time on one day, give an overnight homework assignment to collect leaves, make observations of these in a brief time the next day, and so on until the series of small observations is covered in as many days.

For the younger Band 2 children, the details on compound leaves needs to be abbreviated.

Materials.

-Leaves on the campus, in the neighborhood, or brought from home.

Problem:

Distinguish between simple and compound leaves.

Procedures in Brief.

Any system for teaching leaf differences which works and is interesting to your students is the right one for you to use. Here is one system you might try, either as given, or modified to your needs.

1. Collect leaves.
2. Teach some preliminary vocabulary (see #2 below) and teach the presence of the axillary bud as the criterion for recognizing a leaf.
3. Distinguish between simple and compound leaves.
4. Observe the variety of simple leaves.
5. Observe the variety of compound leaves and learn some vocabulary.
6. Report observations in notebooks.

Procedures in Detail.

1. Collect leaves.

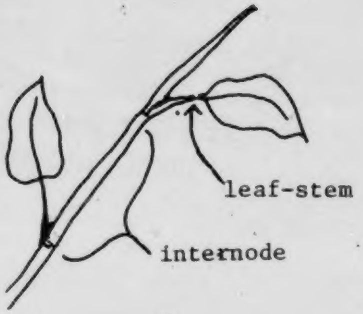
This may be done by the teacher and class together, spending the first part of the class period in gathering leaves; or

The teacher may provide a large bundle of leaves; or

Previous to the day of the leaf class, assign as homework the bringing in of a variety of leaves and branches.

2. Preliminary Vocabulary.

Words with an * are more important.



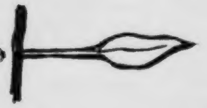
The singular is LEAF* (not leave).
The plural is LEAVES* (not leafs).

The bumpy place on the stem where the leaf is attached is called the NODE.*

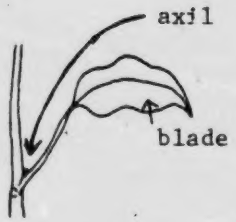
The distance along the stem between two nodes is called an INTERNODE.

The small stem which connects the leaf blade to the main stem is the LEAF-STEM.* Another name for leaf-stem is PETIOLE.

Notice that the leaf does not stick straight out from the stem like this:



The leaf or leaf-stem slants upwards as it comes out. This makes an angle between the stem and the leaf-stem. This angle is called the AXILLARY ANGLE, or AXIL.*

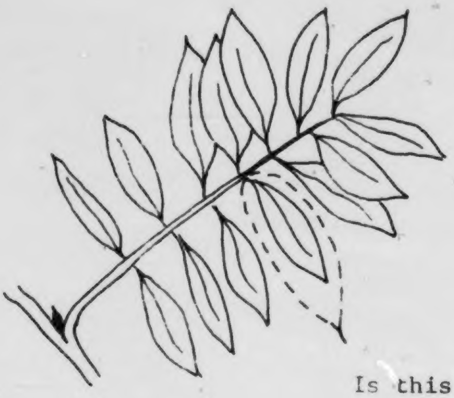


The flat, green part of a leaf is called the BLADE.

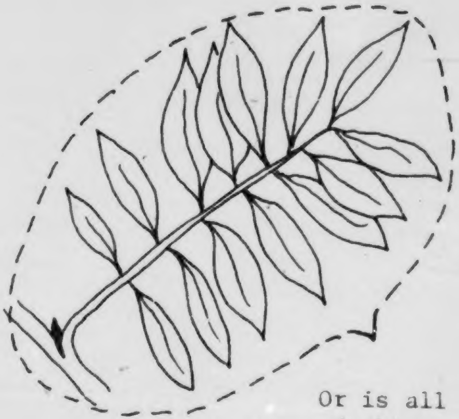
3. Distinguish between simple and compound leaves.

Use branches of shower tree, or any of the mimosas such as monkey pod, as examples.

When we look at a branch like this, should we call each individual blade a leaf, or should we call a group of blades one leaf?



Is this
a leaf?



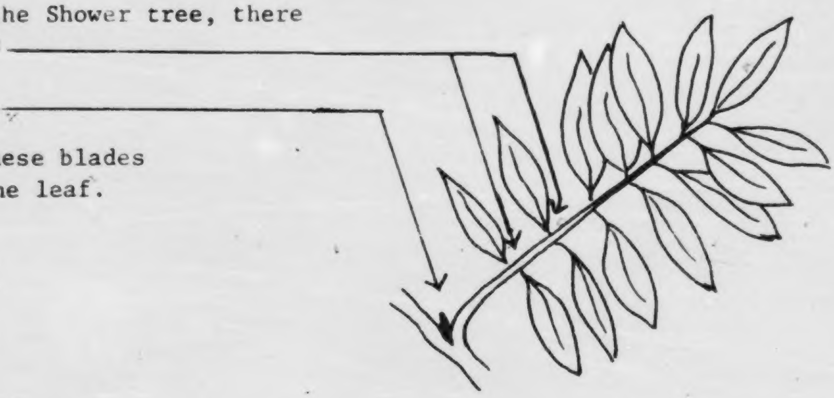
Or is all
of this
one leaf?

Botanists have agreed on a standard for determining how much makes up one leaf. This standard is: The presence of a bud in a leaf axil is the mark of the beginning of a leaf. Whatever extends outward from that spot counts as one leaf. A leaf may be one blade; or a leaf may include many small blades.

In the case of the Shower tree, there are no buds here

The bud is here

Therefore all these blades together make one leaf.



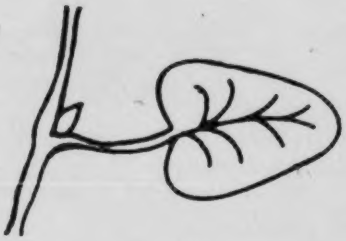
With the definition for leaf clarified, the students may sort the branches and leaves in the classroom into two piles.

Pile 1. Leaves consisting of one blade. These are called SIMPLE LEAVES.

Pile 2. Leaves consisting of many blades or LEAFLETS. These are called COMPOUND LEAVES.

4. Observation of Simple Leaves.

A SIMPLE LEAF is a leaf which is all in one piece, not divided into LEAFLETS A simple leaf has one leaf stem with a bud in the axil.



Problem.

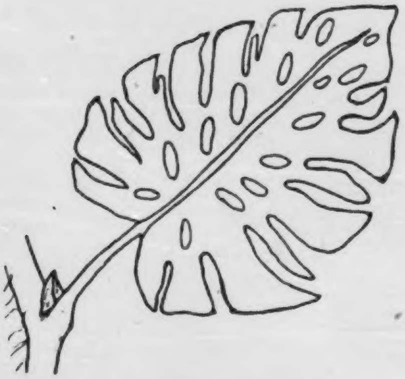
How many different shapes and sizes of simple leaves can you find in your neighborhood?

Look at the leaves which were sorted into two piles. In the pile of simple leaves, how many shapes and sizes can be found?

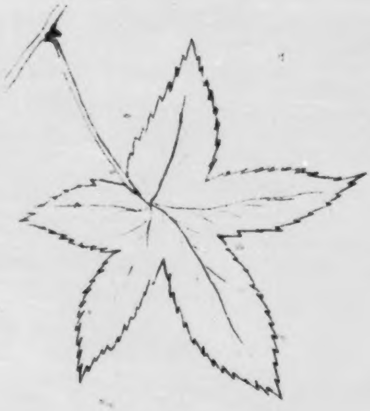
Look at home and in the neighborhood for more simple leaves.

What is the biggest simple leaf you can find? The longest? The smallest? The most beautiful? The plainest? The most frilled? The most unusual?

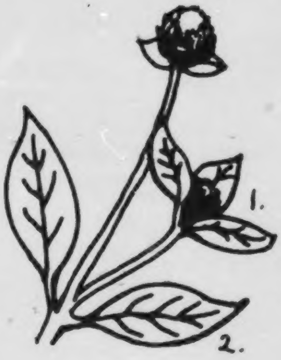
Here are some examples of simple leaves which may trick you:



Monstera has indentations and holes; but it is still a simple leaf with one leaf-stem.



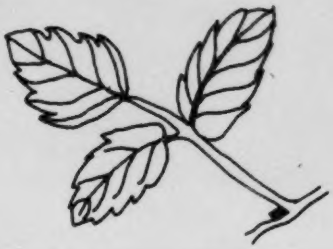
Castor bean leaf has many notches and frilly edges; but it is a simple leaf because it is all in one piece with a bud in the axil of its one leaf-stem.



The globe amaranth branch and flower (#1) was once a bud in the axil of a simple leaf (#2).

5. Observation of Compound Leaves.

A COMPOUND LEAF consists of several or many separate leaflets. Only the main leaf-stem has a bud in the axil. There are no buds at the bases of the leaflets.



Problems:

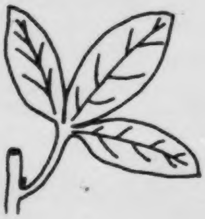
How many different kinds of compound leaves can you find in your neighborhood?

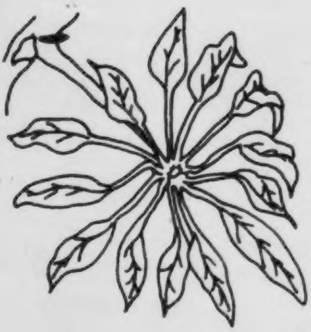
Are compound leaves found chiefly on woody plants or on herbaceous plants? What is the largest compound leaf on the campus? . . . in the neighborhood? Which is the smallest? Which is the most complex?

You may wish to have the children work on these problems by themselves for a while (. . . minutes in class . . . several days homework). They may bring compound leaves to school to compare and share.

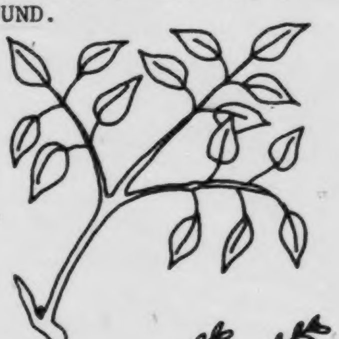
After the students have achieved some awareness of what a compound leaf is, you may wish to stop here and go on to the next topic; or you may go on to further details about compound leaves as noted below.

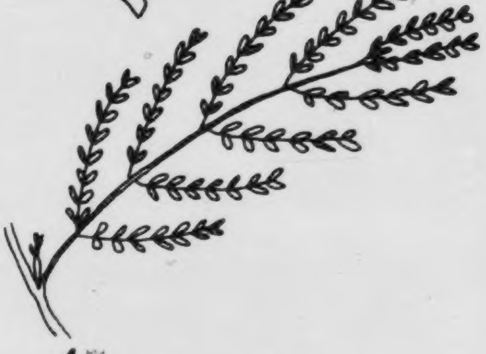
Compound leaves in which leaflets fan out from a common center, like fingers spreading out from the palm, are called PALMATE COMPOUND.



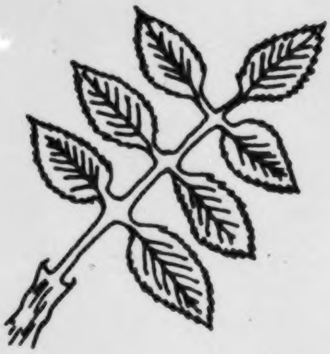


A compound leaf with the leaflets feathering off from along the central stem are called PINNATELY COMPOUND.

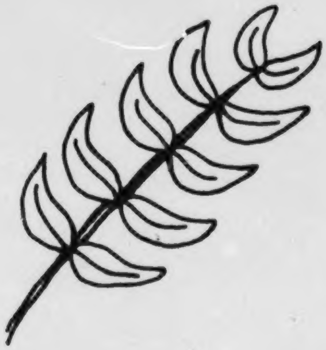




If a pinnately compound leaf ends with a single leaflet at the tip, it is ODD-PINNATE.



If a pinnately compound leaf ends with a pair of leaflets at the tip, it is EVEN-PINNATE.



6. Reports.

Rather than the formal report with problem, data, and conclusion; the notebook report on leaf observations may be a listing of notes and illustrations with names and vocabulary; perhaps with some remarks about the observations.

Pilot Teacher Comments.

One teacher who loaded almost the entire leaf vocabulary onto her 4th graders asked them afterwards to write their comments about the leaf observation lesson. One student wrote: "I never knew the difference between a simple and a compound leaf until I came to 4th grade!" Another wrote: "The part I liked best was learning all those big words for leaves."

A number of teachers have mentioned good interest in their classes during one-period observations and activities; but a rapid falling off of interest if the same lesson goes on for two periods, especially if the classes are separated by more than a day.

4-C LEAF COLORS, TEXTURES, SHAPES. Bands 2 and 3

Introduction.

This is a simple awareness and appreciation exposure lesson.

At the end of this activity, the students will not be equipped to pass a botany examination on leaf morphology. But the chances that they might someday open a book on the subject are greatly increased if they go away from this class with the inner feeling that leaves are beautiful, and interesting, and worth looking at.

This topic is particularly amenable to correlation with art, poetry, music, and story-telling.

Materials.

-Leaves from campus, home, neighborhood.

Problem:

What colors, textures, and shapes can be found in leaves?

Procedures.

The best procedure for an observational topic such as this one is whatever spontaneously leads to appreciation and awareness. Following are a few suggestions for points to observe during a campus or park tour, or in the classroom, as feasible.

Colors of Leaves.

Points to observe:

Are all green leaves the same shade of green?
Are all leaves on the same plant the same color?
Is a leaf the same shade of green on the top and bottom surfaces?
Are new young leaves darker, lighter, or the same color as older leaves?

How many different colors, and shades of colors, can you find in Croton leaves? in Coleus leaves? in ________ (a colorful plant on campus)?

Long-term project: Put a potted plant of coleus or colored caladium leaves in the full sun for a month or so and then in deep shade, or vice-versa. The color development is quite different under the two conditions. Keep data and report results.

Make a picture or mosaic by cutting out and assembling colored portions of leaves. The picture lasts only a day or two but the value is in the doing of the task rather than in its permanence.

Have any children been in the temperate zone in autumn? Perhaps they could describe autumn leaves to the class. Maybe the teacher could tell a story or show samples or pictures of autumn leaves and bare trees.

If you were a forester, you could look at a wooded hillside from the other side of a valley and pick out every kukui tree, even if you were too far away to see the shapes of the leaves or even the shape of the tree. Do you know how?

Teacher Background Information.

The "whitish" patches among the massed green vegetation on hillsides mark the positions of the kukui trees. The new leaves at the ends of branches are covered by small, white, star-shaped plant hairs. The hairs on the new leaves reflect the sunlight and make the kukui trees stand out prominently against the surrounding darker green trees. This observation is best saved for a field trip during which the white kukuis may be seen on a distant green hillside.

The green in leaves is caused by a pigment called CHLOROPHYLL. Many other colors of pigments may also be found in leaves, either alone or in combination. White portions in leaves are usually the result of the absence of all pigments and the presence of tiny air bubbles inside the leaf.

In the temperate zone, the drop in temperature in Fall causes chlorophyll to degrade chemically and be withdrawn from the leaf. The loss of chlorophyll allows the other pigments (reds and yellows) which were present all along, to become visible while at the same time some new pigments, especially reds, are developed.

Texture of Leaves.

Points to observe:

How many different kinds of "feels" can you find in leaves.

Look for leaves with hairs, waxy surfaces, velvety surfaces, rough surfaces.

Leaves may feel thick or thin. Do leaves feel wet or dry to the touch?

When the sun shines on leaves does it make them warm? Or do they feel cooler than the surrounding air? Or do they feel the same temperature?

Some leaves are stiff and others seem limp. Is the same kind of leaf stiff at one time and limp at another time?

What is the "hardiness factor" of your campus leaves? Ti is very hardy and stays fresh and green for days after it is picked. If you gave ti a rating of 10 for being most hardy, and if 0 stands for immediate dying or wilting, how do the leaves on the campus rate for hardiness after picking?

You can cut yourself severely by rubbing the wrong way along the edge of a hala leaf. Do any other leaves in your neighborhood have cutting edges?

Shapes of Leaves.

Points to observe:

Can you find two leaves exactly alike in size and shape?

How much variation, if any, can you find in the shapes of leaves on the same plant?

Is there a gradation in leaf size and shape as you move along the same branch from the base toward the tip; or in leaves on lower or higher branches?

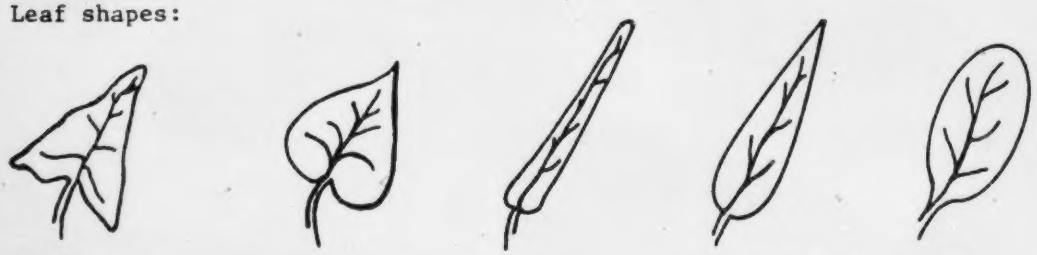
The first leaves (not counting the cotyledons) put forth by a young plant are called juvenile leaves. Juvenile leaves are often less indented or less complex than leaves put out by a mature plant. Can you find any examples of juvenile leaves?

For a collection of leaves with the "fanciest" shapes, the neighborhood weeds are an excellent source.

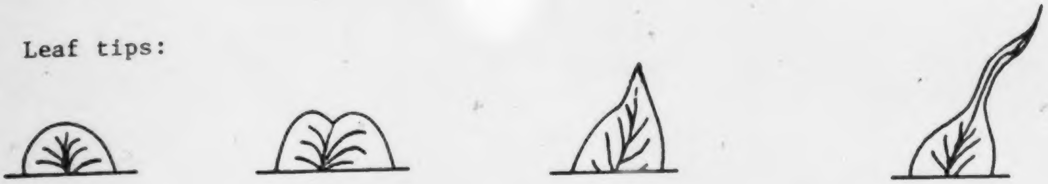
Did you ever see a leaf which is broader than it is long? What is the most unusual shaped leaf you have ever seen?

Below are examples of some leaf shapes for reference.

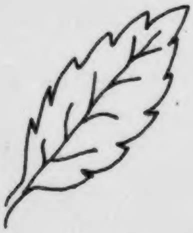
Leaf shapes:



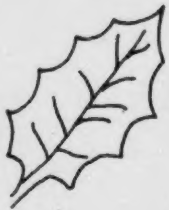
Leaf tips:



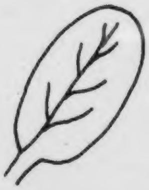
Leaf margins:



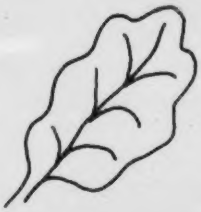
saw toothed



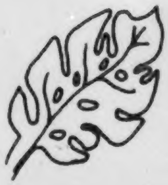
sharp cornered



smooth edged



wavy



cut in

Notebook Reports.

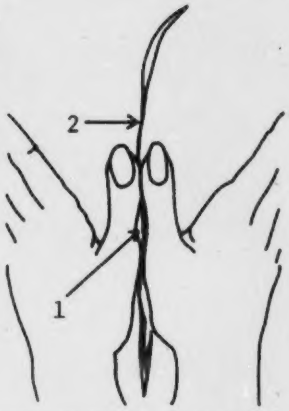
Leaf observations may be recorded informally in the notebook together with illustrations, drawings, and student comments.

Additional Activities.

A grass blade can make a whistle.

Hold a blade of grass taut between your thumbs. Blow onto its edge.

#1 = Open space between thumbs.
#2 = Grass blade pulled taut.



Leaves can sometimes be found under trees in which the green parts have been eaten out and what remains is a beautiful, lacy outline of leaf veins.

Look for these. Mount them on paper as an art expression. You may spray them with metallic paint or other colors before mounting.

4-D LEAF VEINS. Bands 2 and 3

Introduction.

The value of looking at leaf veins will become apparent much later when the distinction between monocot and dicot plants will be a topic of investigation. At that time, the parallel and the net veining in leaves will be one of the chief clues in sorting the two categories of plants. For now, the veins can be considered simply as an observational point to be noted.

The two vocabulary words which will be needed later are parallel veined and net veined. The remainder of the vocabulary in this topic is less essential.

Materials.

-Leaves from campus, home, neighborhood.
-Pins, 1 per student.

Problem:

Observe the veining in leaves.

Distinguish between parallel and net veining.

Procedures in Brief.

This class might well be held out-of-doors.

1. Observe the veining in leaves.
2. Learn distinction between parallel and net veining in leaves.

Procedures in Detail.

1. Observe the veining in leaves.

Have students observe the veining on the undersides of leaves where the veins are often more prominent than on the upper surface.

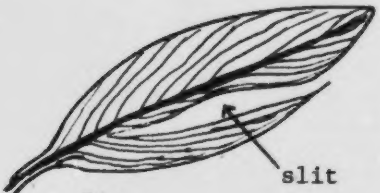
Solicit guesses as to what these lines in the leaf might be, (continuations of the vascular bundles in the stem); where they are going, (to all parts of the leaf in finer and finer subdivisions); and what they might be doing, (carrying water and sap with nutrients to and from the leaf blade).

These pipe lines are called VEINS.

2. Distinguish between parallel and net veining.

The single large vein down the center of the longer leaves is called the MIDRIB.

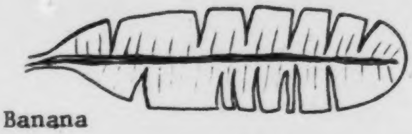
Stick a pin through the leaf near its base close to the midrib. Using the pin as if it were a knife, rip the leaf, pulling outwards and toward the tip of the leaf.



Ti

If the pin ripped the leaf neatly with a long, clean slit, the veins are PARALLEL.

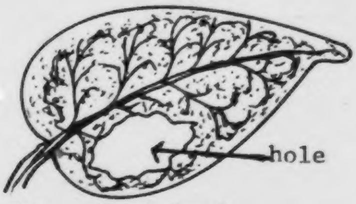
Parallel veins may run from the base toward the tip of the leaf, as in Ti.



Banana

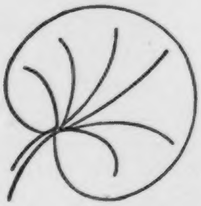
Parallel veins may sometimes go from the midrib out to the side edges of the leaf, as in banana.

If the pin ripped a ragged hole in the leaf, the leaf is NET-VEINED.



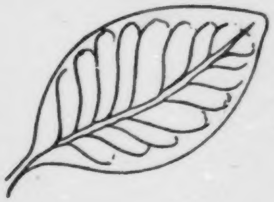
Net-veined leaf

Some net veined leaves have several big veins which fan out from one place at the base of the leaf to all directions, like fingers spread out from the palm. These leaves are called PALMATELY NET-VEINED.



Palmately net-veined

Some net veined leaves have one central midrib with side veins branching off from it like a feather. These are called PINNATELY NET-VEINED.



Pinnately net-veined

Can you find examples of parallel veining and of net veining in leaves in your yard or neighborhood?

Notebook Reports.

This might be another informal observational report with illustrations rather than data.

4-E LEAF ARRANGEMENT ON THE STEM. Bands 2 and 3

Introduction.

This particular topic will have only a minor tie-in with the work to come later. For that reason it could be skipped or skimmed over without impairment to later topics. However, leaf arrangement is interesting to botanists, and perhaps to some of your students who have a bent toward mathematics. Nature seems to have anticipated some of the number series of mathematicians by arranging leaves on stems in patterns which can be expressed in mathematical terms.

Materials.

-Branches of plants growing on campus or at home; a pineapple fruit.
-pins
-thread

Problem:

Look for patterns in the way leaves are arranged on stems.

Procedures.

Here are three ideas, one of which you may find useful for presenting this topic:

Select some branches and ask the students if they can see any repeated patterns or "rhythms"in the placement of leaves along the stem. If and as they find patterns, confirm their observations by showing the patterns they found among those illustrated in the Teacher Background Information below; or

Take the class out on campus and while going from plant to plant observe the leaf arrangements on the stems. Match the types of arrangements found with those illustrated below; or

Explain and demonstrate on overhead or blackboard some of the patterns illustrated below for a few minutes in class. Then the students could look for these patterns on their own time, bringing in and showing their findings as they make them; or

Any other way you want to present leaf patterning.

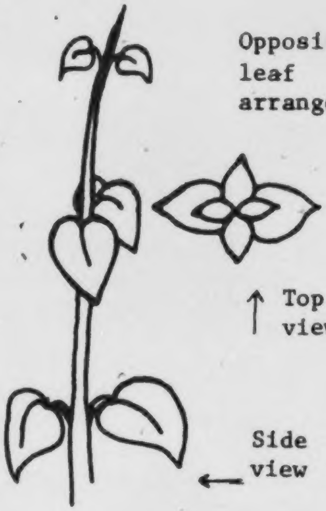
Teaching Background Information.

The vocabulary and mathematics of leaf arrangement can become quite complex. These illustrated notes are a teaching reference which can be pared down to meet the interest and ability level of a given class.

The pattern formed by the arrangement of leaves on stems is called PHYLLOTAXY or PHYLLOTAXIS.

Opposite Leaf Arrangement. (Decussate phyllotaxy)

2 leaves per node.
Each pair of leaves sits crosswise to the pair immediately above and below.



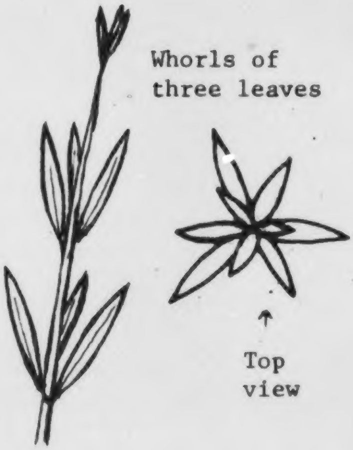
Two-ranked Leaves.

The leaves come out in pairs very closely following one another so that leaves overlap. All the pairs are in the same plane giving the plant a flat appearance. e.g. Traveller's Palm as well as other members of the banana family in lesser degree.

Often each pair is slightly offset from the pair below, forming a spiral e.g. Pandanus or Hala.

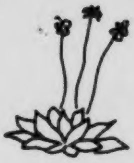
Three or more leaves per node. (Whorled Phyllotaxy)

Oleander has 3 leaves in each whorl. Viewed from the top, each set of 3 leaves seems to fit in the spaces between the 3 leaves immediately below or above. Oleander sometimes bears one branch with 4 leaves per node instead of 3. Such a branch is traditionally called the Sultan of the Oleander. Can the students find any Sultans?



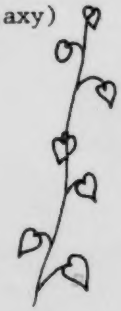
Allamanda commonly demonstrates either 3 or 4 leaves per node. It may exhibit 5, rarely 6, and 7 were found in one instance. Allamanda always puts forth 2 leaves on the first node of a branch following the flowering node. A few nodes sometimes have only one leaf. A math student might like to do a statistical inventory on numbers of leaves per node in Allamanda,e.g. most common number of leaves per node, variations from the norm, variations along the same branch. There are statistical differences between the large flowering and the small flowering species of Allamanda.

A ROSETTE is a cluster of leaves set so closely together that the internodes all but disappear. The basal leaves of many weeds are rosettes. The ends of the branches of plumeria may be called rosettes.

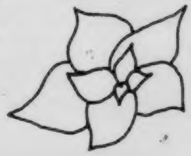


One leaf per node. (Alternate or Spiral Phyllotaxy)

Each leaf comes out of the stem above and to one side of the leaf below. Viewed from above, the leaves form a spiral or helix around the stem. Because the leaf blades turn toward the light and the stem twists, the spiral is sometimes difficult to follow especially in the case of vines.



side view

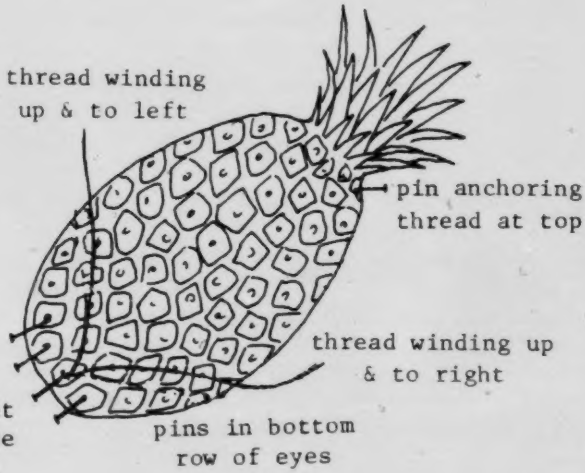


top view

The arrangment of bracts, fruits, or other structures in some plants are often compressed spirals. Pine cones (not iron wood cones) and pineapples are two examples of spiralled fruits.

The spiral arrangement in a pinapple can be examined thus: insert a pin into the bottom row of "eyes" around the base of the fruit. Attach a thread to each pin. Wind each thread around the pineapple going from one eye to the eye next above and to the right of it. When reaching the top, anchor the thread with another pin in the top row of eyes.

Then choose threads of a different color and attach these threads to the pins at the bottom. Wind each thread around the pineapple following the spirals in the opposite direction, i.e. let each thread cross the center of each eye above and to the left of the eye below.


thread winding up & to left
pin anchoring thread at top
thread winding up & to right
pins in bottom row of eyes

Most Hawaiian pineapples have from 110 to 180 eyes arranged in 8 spirals moving around the fruit in one direction, and 21 spirals going the other way around. How many spirals are in the pineapple you measured?

Look for other examples of spirals. Check the Hala tree fruit, among others.

Wind a thread from leaf to leaf around a stem which has one leaf per node and note the spiral effect.

4-F LEAF, SPECIAL CASES. Bands 2 and 3

Introduction.

These special cases are miscellaneous items which point up some of the unusual leaves and conditions found among our local plants. There are undoubtedly many others which can be included in future editions of this booklet as teachers call them to our attention.

This topic appeals to people who enjoy curiosities and exceptions to the usual. It can help stimulate interest and attention to plant observation.

Time Frame.

Whatever you decide to give to it.

Materials.

-The plants, as indicated for each case.

Procedures.

This miscellaneous collection of leaf types may be called to attention in any way you wish or can, depending on your campus potential and student curiosity. No problem or activity statements are spelled out as such. The background information for teachers includes suggestions which can be developed into activities to use as desired.

Teacher Background Information, and some suggestions.

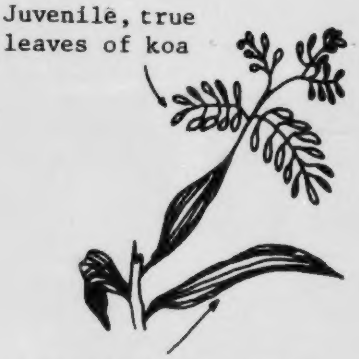
Modified Leaves.

Bring a cactus to school. Ask the children where the leaves are. The students may have various speculations.

The leaves are the prickles. The stem is swollen and juicy.

Phyllodes.

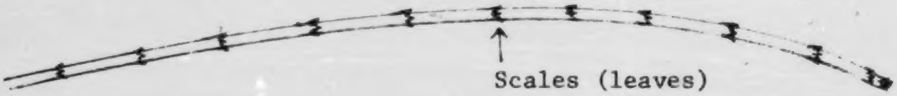
The leaves of the koa tree are not leaves. What looks like leaves are leaf-stems which have become flattened and curved. The technical name for these leaf-like parts is PHYLLODES.


Juvenile, true leaves of koa

Phyllodes (broadened leaf-stems) which serve as the mature "leaves".

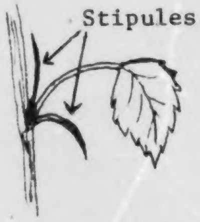
Scales.

The ironwood tree seems to have long "pine needles" which hang in limp clusters. The "needles" are branches each consisting of a chain of branchlets joined end to end. The leaves are tiny scales set in a circle at each joint.



Stipules.

Look at a hibiscus bush at the place where a leaf is attached to the stem. On each side of the axil is a green "whisker". These are called STIPULES. All members of the hibiscus family, as well as some other plants, have stipules. On the Hau tree, the stipules are broad and flat and look almost like small leaves attached at the base of each leaf-stem.

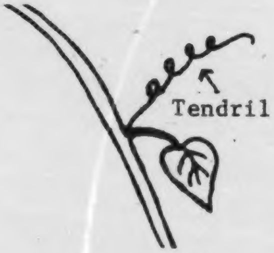


The stipules at the base of a rose leaf look like two squarish "wings".

Can you find stipules of various shapes and sizes?

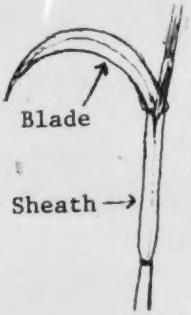
Tendrils.

Attached to the stems of some plants, sometimes in the place of a leaf, sometimes growing from the axil, are "curly-cue" elastic-like stems wound up like a spring. These are TENDRILS. They help vines to cling to other objects.



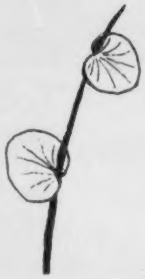
Leaf Sheaths.

Grass leaves have two sections. The BLADE is the part which extends out from the stem. The SHEATH is the part which encloses the stem. The bottom of the sheath is attached to the node.

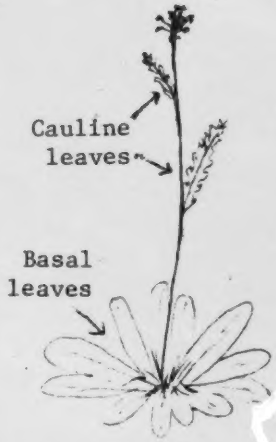


Sessile Leaves.

Sometimes leaves have no leaf-stem. The blade grows right out of the stem. Examine some of the weeds in the school yard as a good source of finding sessile (no stem) leaves.



Basal and Cauline Leaves.



Many plants, especially many of our common weeds, have leaves of two different types. At the base of the plant near the ground they have a thick circle of leaves in a rosette shape. These are called BASAL leaves.

The single tall stalk which grows up from the center of the basal rosette usually has a flower at the top. Along the sides of the central flower stalk are leaves of a much different shape than the basal leaves. These leaves on the central stalk are called CAULINE LEAVES.

Insectivorous Plants.

Garden shops sometimes sell little plants whose leaves are modified to trap flies and other insects. Insectivorous plants are usually native to bogs where the high acidity of the soil slows the uptake of nutrients by the roots. The leaves compensate by trapping live protein.

Some of our high-altitude Hawaiian bogs have insectivorous plants but do not pick and carry those off for your classroom terrarium. Purchase of the garden shop variety, grown for the purpose of sale, is less damaging to the delicate balance in our bog ecosystem.

Bulbs.

An onion is made up of layers and layers of broad leaf-stems huddled around a small short stem at the base of the onion.

A cabbage is made of layers and layers of leaves pulled close together into a head.

Sleeping Leaves.

Hawaii has many plants whose leaves "go to sleep". The mimosas (monkey pods and such) fold, or at least droop, their leaves at night.

A student with a camera light meter might care to do a project to check on what degree of darkness is associated with the folding of the mimosa leaves; and how light it is in the morning when the leaves open. Leaves sometimes fold in the rain. Is this a function of the wetness or of the darkness? Design a test for finding this out and take data.

The Sensitive Plant (Mimosa pudica), a pasture weed in Hawaii, folds its leaves very rapidly when it is touched. Grow a sensitive plant in a pot in the classroom. A student interested in taking on the project might keep data on which of the joints move when the plant is touched and in what order they fold.

Another student project could center around timing the closing and reopening of the leaves when touched. Does repeated touching make the plant "tired" so that it reacts more slowly after a while, or does it always respond with the same rapidity no matter how often it is touched?

Projects such as the above can be accompanied by scientific reports which follow the formal report plan outlined in the PROGRAM MANUAL.

Monolayering.

Lie under a monkey pod tree and look up to the sky. Do you notice that the leaves which form the dome or "canopy" of the tree are arranged next to each other so that seldom does one leaf overlap another? The canopy is only one leaf thick. Some other trees also have a MONOLAYER of leaves forming the canopy of the tree allowing each individual leaf to have full sunlight.

Leaves Which Work for Us.

The following list could be made into a game, or a library research project.

What useful items can you make from these leaves?

Lauhala (baskets, purses, bags, mats)
Coconut fronds (thatch, walls, hats, baskets, fish traps. From the midribs can be made needles, flower holders, brooms.)
Pili grass (thatch)
Spinach and taro leaves (food)
Ti (skirts, table clothes, dishes, laulau wrappers, decorations)
Tea (beverage)
Bay and all-spice leaves (spices)
Maile (lei)
What other useful leaves do you know?

A reverse approach is to give a use, such as basket, and ask which kinds of leaves are useful to make one.

5. ROOTS BANDS 1, 2, 3

Introduction.

Roots are parts of plants we sometimes fail to notice but which we cannot ignore if we are to understand plant anatomy and growth.

The root investigations offer a change of pace following the study of leaves. The leaf topics engaged the students chiefly in collecting and quietly observing. By contrast, washing out roots with a hose is noisy, splashy, and action-oriented.

The word "soil" appears frequently in this topic. Soil scientists groan in anguish when people say "dirt" (which the soil scientists consider a "dirty word"), when they really mean "soil" (which the scientists consider to be a delightful, earthy substance). Soil is weathered (pulverized) rock mixed with organic matter in a defined structure. The intergranular spaces, occupied by air, water, and various nutrient salt solutions, are penetrated by plant roots.

Time Frame.

One to several class periods, depending on amount of detail taken.

Materials.

-Potted plants which you do not mind ruining.
-Garden containing some weeds or plants which can be uprooted.
-Hose with nozzle
-Shovels
-Hand lenses
-Notebooks for Bands 2 and 3

Problems:

The following problems and questions might be used to stimulate discussion with the class as a whole, or they might be given as individual assignments to different groups in the class to investigate. You may wish to select only a few of the ideas for more careful examination. You might also have additional ideas of your own.

1. What qualities (shape, color, toughness, etc.) do roots have compared to stems of about the same size?

2. How tightly does soil adhere to roots? Use a hand lens to check tiny soil particles on fine roots. Does soil stick to roots more tenaciously than soil sticks to hands or shovels? Test out the soil-holding power of roots, skin, and shovels by using the same force of water from the hose on all three.

3. What is the length of the longest single root you can find? What is the length of the total root system of any one plant. One way to find out is to separate the roots into individual pieces. then lay them end to end and see how long a line they make.

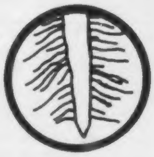
(Teacher's note: The total root system of plants is usually longer than we expect it to be. Some cereal grains are reported to have root systems which measure more than a mile in total length.)

4. Can anyone find big, fat (fleshy) roots? Do the plants with the big, fat roots also have other small roots? What do you think the big roots are for? What might little roots be for?

(Teacher's note: Large, fleshy roots, such as sweet potato, carrots, asparagus fern, are starch storage structures. Small roots chiefly function to anchor the plant and to absorb water.)

5. Using a hand lens, see what details you can find on roots, such as side branches, small rootlets, and root hairs near root tips.

(Teacher's note: Under the microscope root hairs may look something like this. They may be seen even with the naked eye on roots grown in an enclosed jar or moist terrarium. Root hairs are the specific organs of water abosrption.)



6. Take a carrot apart and find the two differently colored portions of the root. Do other roots show this difference? What else can you see inside roots?

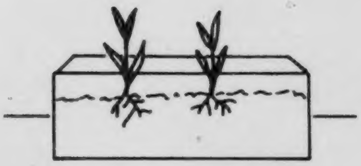
7. Can you associate tap roots and fibrous roots with any particular groups of plants? For example, are the tap roots found mostly on woody plants, or herbaceous plants, or big plants, or small plants, or doesn't there seem to be any particular tendency? Do fibrous roots seem to belong to certain types of plants?

(Teacher's note: Monocot roots are always fibrous roots. All grass roots are fibrous. Most trees have tap roots except coconut which, being a monocot, has fibrous roots.)

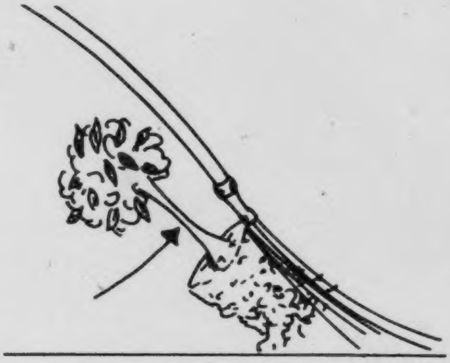
8. Dig up the entire root system of a nut grass. Make a display of the nuts, showing how they are arranged underground. (Note: this is a very difficult excavation task.)

Procedures.

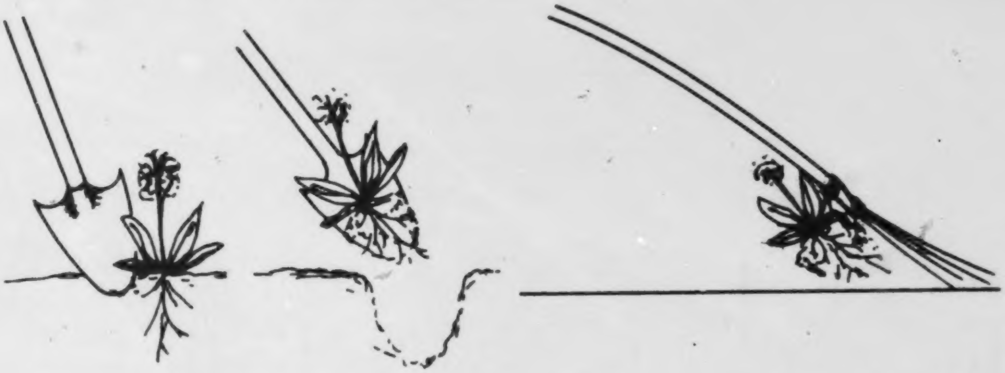
Suggested techniques for getting at roots for observation:



1. About 10 days or 2 weeks before this class, plant a variety of vegetables or other seeds in a box of vermiculite or other loose potting soil. The young plants which grow can be pulled up by hand with roots clean and intact.



2. If a garden with well cultivated soil is available in which some young weeds have begun to grow, the garden may be well watered the day before this class. The weeds may then be pulled up gently by hand without breaking.
3. unpot an old plant. After removing the pot, hose out the soil from the roots as shown in the diagram.
4. Dig up weeds or garden plants and then hose off the soil as shown below.



Adaptations must be made to accommodate the ages and abilities of the students, the availability of garden plants, of old potted plants, and hose facilities.

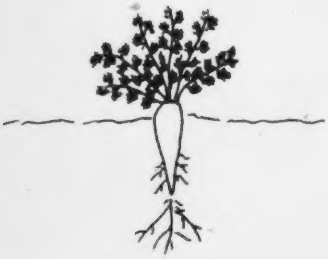
Band 1. You may prefer to hose out a few roots yourself, either before class or while the children watch. They can then pick over the clean roots. Band 1 children can note the differences among roots, discuss their lengths, strength, shapes. They might be able to learn the terms Tap and Fibrous. The chief task of Band 1 children is to learn that roots exist and to become aware of a few root characteristics.

Band 2. Using diagrams on blackboard or overhead, explain how to unpot or dig up a plant and hose out the roots. Each group of 3 to 5 students could then go outside to dig and hose. Assign appropriate problems which fall within their scope of ability.

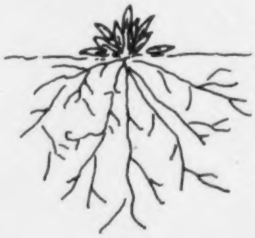
Band 3. Look over the root problems yourself or with the class. Group the students according to the number of problems to be pursued. Band 3 students should be able to plan for themselves, with minimum help, how to investigate their problem. See the PROGRAM MANUAL for investigative and reporting procedures.

Vocabulary: TAP and FIBROUS

These two words can be taught informally out-of-doors as the different types of roots appear during the washing process.



Some plants have a strong, thick central root called a TAP ROOT. Small roots grow out from the main tap root. A carrot is a tap root. Many trees have tap roots.



Some plants have a network of many long, small roots, called FIBROUS ROOTS. Grass has fibrous roots.

Additional Problems.

The following challenges may be offered to advanced students interested in library or individual research. The problems can be cut out, if desired, and pasted onto file cards.

1. Find out what aerial roots are.

   Explain them to the class with the help of pictures and examples.

2. What are prop roots?

   Explain them to the class with the help of pictures or sketches you have made.

3. What kinds of roots hold vines onto rock walls? Do they differ from ground roots? Do they affect the wall they grow on? Show examples to the class.

4. What are haustoria?

Explain their habits and function to the class.

5. How do the roots of the mangrove sprout? Describe the grown roots of the mangrove.

(Teacher's note: The first root sprouts from the seed while it is still attached to the parent tree.

6. Look at road cuts as you travel over various parts of the island. Can you see any roots exposed which seem to be attached to plants growing up on top? Take pictures or make sketches and report to the class.

7. Make a report to the class about orchid roots. Tell about the kinds of media orchids grow in (include air and soil as well as the usual haupu). Tell the class how orchids are cared for and transplanted.

With a hand lens, take apart and examine orchid roots which grow attached to the outside of cement pots. The thin-skinned spongy tissue around these roots is called velamen. Can you find out how the velamen works?

8. What do these words mean? All of them refer to roots in some way.

adventitious
epiphytic
mycorrhiza
nodules
primary root
root cap
root knees

Answer to puzzle on next page:

If you tied the stem to a stake you could stem the tide of fate.

The Case of the Eliding Advisor

The wind blew down a young tree which Mr. Conroe had recently planted. His wife, Fran, ran out to assist but she became so excited her words all ran together. Fill in the letters and then separate the words to find out what good advice his wife gave to Mr. Conroe. Eight letters are already filled in to give you a start.

	F	Y							T	H					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

									O	U			U	L	D
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

				T												
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49

1.	Conceited person's favorite pronoun.
4.	Not in.
7.	Seeing organ.
8. 9.	Abbreviation for editor.
12. 13. 14.	Time zone in which New York is. (Ab.)
15. 16.	Printers' measure.
17. 18. 19. 20. 21.	Slice of bread, slightly browned
22.	One.
23. 24. 25.	It locks and unlocks.
28. 29.	Abbreviation for a business.
33. 34.	Abbreviation for a road in the city.
35.	Most used letter in the alphabet.
36.	Precedes "Good" in TV commercials.
38. 39.	_____and she.
40. 41.	Green leaf used for hula skirts.
42. 43.	Prefix meaning "down"
44. 45. 46.	Keep ____the grass.
47. 48. 49.	What you did at breakfast this morning.

6. FROM BUD TO SEED

Introduction.

This topic is intended to help students realize the sequential development from bud, to flower, to fruit with seeds. All too often, children assume that plants bear such items in random order. However, if you discover your class already understands that fruits are the development of flower ovaries which in turn open from buds, this topic could be skipped over.

This activity is indicated for Bands 2 and 3. It is assumed that Band 1 children are not yet able to handle the data collecting operations nor sustain sufficient long-term interest to follow the development of a fruit from a flower or bud. But any primary teacher who can fit this concept to the primary level is welcome to do so. Farm children grasp at an early age that flowers precede fruit so the idea must be learnable by the very young.

Eventually the students will have to deal with the complete life cycle of a plant from seed to seed. This topic considers only a portion of the life cycle. This shortens the time span for observation. To further speed things up for impatient youngsters, it is helpful to choose plants which have rapid maturing rates.

Time Frame.

-One period to set up the plan of the experiment.
-Thereafter, a few minutes daily for 1 or 2 weeks for making observations.
-A final concluding period.

Materials.

-Some mature weeds in the neighborhood, or in classroom pots.
-Plant tags, purchased or home made.
-Notebooks.

The Haole koa, which grows by almost every wayside throughout Hawaii and throughout the year is a particularly good subject for this topic because it demonstrates buds, flowers, and seed pods in continuous and rapid succession on the same branches.

A cultivated flowering tree or shrub or herb may happen to be in flower and fruit in a given school neighborhood at the time of this experiment.

Seasonal changes in flowering and fruiting of neighborhood mango trees and other plants may be called to attention at appropriate times.

A time-lapse movie showing the opening of flower buds and the development of flower to fruit might be found in the film library.

Weeds make excellent subjects for this topic because:

1. Weeds have a relatively short time span from flower bud to seed pod. Cultivated plants usually take much longer.

[illegible]. Weeds in Hawaii flower and fruit during most of the year thereby not limiting this investigation to any one season.

3. Weeds are generally available for close-by, daily observations. Even well-manicured campuses are likely to harbor a few weeds near fences or in remote corners.

Problem:

What relationship exists between buds, flowers, fruits, and seeds?

Procedures in Brief.

1. Select a plant to study. See suggestion under "Materials" above.
2. Set up an experimental plan for observing the progress of bud development.
3. Observe and record daily changes for 1 or 2 weeks.
4. Discuss results.
5. Formal science reports.

Procedures in Detail.

1. Select plant to be observed. Find a neighborhood tree or plant about to come into flower or locate some mature weeds having flower buds sufficiently close to campus to allow daily visiting. If none can be found, dig up and pot several garden weeds and give them plenty of sun in the classroom window will. When they approach maturity, this lesson can begin.

2. Set up an experimental plan for observing the progress of bud development.

Here are some questions which could be used to stimulate interest in the problem:

Does a flower start out as a baby flower and then grow bigger? Or Does it unfold at its full size?

What happens to flowers when they grow old? Does anything grow on the flower stalk after the petals drop off?

List the following items on the board: pods, flowers, buds, leaves, fruits, seeds. Do any of these grow on the plant at the same time? Does any one follow any other one? If so, in what order? Always in that order?

Hopefully these and similar questions will stir up disagreement or uncertainty in the class. This provides opportunity for asking how we could go about finding out what really is the case.

Planning an experiment to find out "what grows when" might proceed as a class effort or you may wish to divide the class into groups and allow time for group planning. Whatever valid plans the students devise are to be preferred to the one described here. If the class is unable to devise any viable scheme, here is one which could be used.

a. Prepare some tags; either purchased identification tags, or home-made small pieces of tag board with string or strong thread attached at one corner.

b. Find some plants (weeds) which have some buds on them. They may also have flowers or pods.

c. Attach a tag with a number on it to each bud or flower or pod. Many plants may be tagged covering a variety of types of plants and kinds of plant parts. The work could be divided among teams.

d. Set up a data sheet to show which tag number belongs to which plant part and permits a recording of observed changes from day to day. If a table for such complex data is too difficult for the students to devise alone, the following sample might help. This sample is already filled in with hypothetical data as a teachers reference only. The number of tags and columns will vary according to the local situation.

Table 1. Observations on What Happens to Parts of Plants over Time.

Tag Number	1	2	3	4	5	6
Plant	Haole koa	Same plant as #1	Same plant as #1	small weed by sidewalk	hibiscus	weed by water faucet
Part tagged	bud	flower	pod	buds in leaf axil	flower bud	small flower
Appearance on Day 1.	round, green, bumpy knob	white, puff-ball	lumpy brown bean	tiny bunch of green stuff in axil	red pointed bud	yellow petals
Day 2	Bigger, green, bumpy knob	droopy, puff-ball	same	same	closed dead petals	green knob growing where flower was
Day 4	no school..................	....	....	....	....	....
Day 5	no school..................	....	....	....	....	....
Day 6	small, green spears stick out of dead flower head.	green spears grew into long green beans.	pod opened and brown seeds spilled out.	same	Nothing left. Old flower and its stem fell off.	Knob growing bigger and turning brown. Has seeds inside.

3. Assist the students as much as necessary to select and tag buds, flowers, and whatever else they decide to watch. If words seem inadequate, a sketch may help to record the appearance.

   Have the students continue daily observations and recording on their data sheets until you notice that there is sufficient evidence to put together a bud-flower-pod sequence.

4. Discuss results.

   Can the students, by themselves, see a temporal sequence in the changes they have recorded? If they need help, the following questions, or others you make up, could assist to clarify a conclusion.

   > What happened to the tagged buds? The tagged flowers? The tagged ______________?
   >
   > Did the same changes take place in every case?
   >
   > Can you see any general pattern of change or any sequence that seems to be followed in most of the cases? What comes after what?
   >
   > Did a seed pod ever change into a flower? Do you think it could or ever would?
   >
   > What seems to come first in the items we observed?
   >
   > Line up a list of items according to what usually seems to grow first, then next, then next.

   With sufficient good data, it can become evident that the usual sequence is bud, to flower, to a pod or capsule or fruit containing seeds.

   Notice that flowers sometimes drop off and never set fruit or seed. Some weeds have tiny axillary flower clusters which are well-nigh impossible to examine without a lens. Some plants, including even some weeds, mature so slowly that two weeks is not enough to note significant change.

5. Reports.

   The data gathering process for this topic provides prime material for a formal science report, following the directions in the PROGRAM MANUAL.

7. FLOWERS

The immediate value of this topic is the pleasure it can yield to careful young observers. Achievement of the primary goal would be evidenced by any child who gathers up a pea or bean flower and exclaims with the joy of recognition, "Look! This is the kind of flower that has a tiny pod folded inside." or "Guess what, I found a plumeria today with 4 petals!"

A more academic but secondary goal for this topic relates to the choice of flower structure as the basis for plant classification in the Linnaean and most modern taxonomic systems. An acquaintance with flower structure will be useful to students later in identifying plant families.

Anatomically, flowers are the most complex parts of plants. As a result, the terminology for flower parts is extensive. Even college students have their difficulties with identifying the intricate parts of flowers. Certainly elementary children should not be expected to master the subject. Elementary teachers need to treat the vocabulary in this topic with a light touch. The key idea is exposure rather than technical mastery.

Few skills,other than observation, are practiced in the pursuit of this topic. As a result, written notes will be of the sketch and vocabulary type, rather than formal scientific reports.

The topic "Flowers" is divided into three sub-topics:

7-A FLOWERS. Band 1 (2 and 3)

7-B THE PARTS OF A FLOWER. Bands 2 and 3

7-C ARRANGEMENT OF FLOWERS. Bands 2 and 3

7-A FLOWERS. Band 1. (2 and 3)

Introduction.

This is a "Look at the pretty flower" appreciation lesson. It manages to rate as a science lesson on the grounds that it promotes observation, an important science skill. But its most important function is to engage student interest and pleasure in the natural world. Without that, students are not prompted later to get into science courses, science books, and especially the out-of-doors where more precise learning may take place.

In content, this activity goes no deeper than Band 1 level. However, older elementary students who exhibit a weak awareness of their natural environment could well profit by attending for a few moments to the observation of flower shapes, colors, and fragrances.

Materials.

-Flowers from home and neighborhood, augmented by pictures of flowers.

Problem:

What shapes, sizes, colors, odors, do flowers have?

Procedures in Brief.

Any method whatsoever which captures the eye and the heart is "legal tender" for this topic.

1. Have students bring in flowers, any and all kinds.
2. Observe shapes, sizes, colors, odors, and special characteristics.

Procedures in Detail.

1. Have the children bring flowers to school, any kind. Pictures and colored slides of flowers could add variety to the collection but at least some of the flowers should be living and gathered by the children themselves to emphasize the connection with the out-of-doors and the growing plant. Look for tiny flowers on weeds and in the lawn.

2. Observe the flowers.

   Let the students tell as much as possible of what they see. Draw out additional observations by questions. Some useful questions might be:

   What are the different colors of flowers we have among our class collection?

Can you think of other flower colors you have seen? Has anyone ever seen a green flower (Bells of Ireland, Obaki anthurium, and others?) Has anyone ever seen a black flower? (There seem to be no truly black flowers.) What different colors and shades of colors can you see in the same flower and even in the same petal? How do the front and back sides of the petals compare in color?

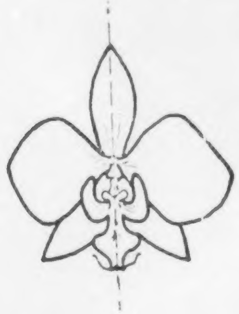
How many of the flowers in our collection have an odor? Are all the fragrances equally strong? Do you have any flowers with no odor? Do any flowers stink?

What are some of the sizes and shapes among the flowers in our collection? Which are the largest and the smallest flowers you have ever seen? Do all the petals on one flower have the same shape; or are some petals of a different shape than others? Orchids are notorious for unusual shapes.

The following distinction between bilateral and radial symmetry is optional for younger students.

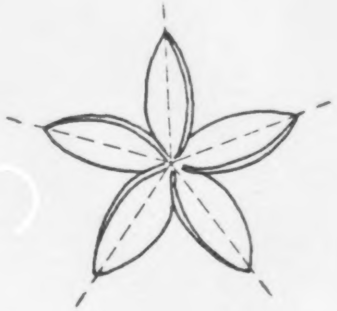
Orchids have bilateral symmetry. If you draw a line down the center you get two halves which are mirror images of each other. Some other flowers also have bilateral symmetry. (bird-of-paradise, poinciana, snapdragon, beans, African tulip, among others.)

(Among animals, dogs, fish, and people have bilateral symmetry.)



Many flowers, such as hibiscus and plumeria, have radial symmetry. If you draw lines from the center outwards, you see the repetition of design in a radiating pattern.

(Among the animals, starfish and sea urchins (wana) have radial symmetry.)

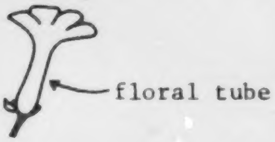


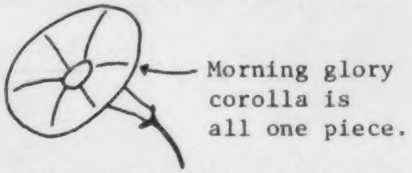
Do flowers feel lighter or heavier than leaves of the same plant? (A torch ginger head may weigh as much as one pound. A white ginger blossom is very light and frail compared to the heavy head and large ginger leaves.)

How sturdy and how frail are various kinds of flowers? How long do flowers stay in bloom on the plant? How long do they stay fresh after they are picked?

Look at the center of your flowers? What is in the center? Are all the centers alike? Some flowers have a "tube" leading up to the petals.

Sometimes the petals are all joined together in one piece; sometimes each petal is separate. Do you have flowers of those kinds in the collection?





Band 1 students who are able might learn the name PETAL and POLLEN and perhaps one or two other terms. (See next topic.)

This topic comes to an end without a report after a reasonable amount of pleasant exposure and while interest is still high. It could merge into an art lesson involving flowers. For the older students, this is a prelude to the next topic involving flower dissection.

You Can Build Yourself A Rose Garden

Directions: Transfer the letters underneath the diagram into the squares directly above them. The letters are all in the correct column but not necessarily in the order in which they are to be moved up. The solid squares indicate the separations between words. When the sentence is complete it will tell you how to plan for a happy future.

			■				■								■
		■				■				■					
				■				■			■				■
■						■			■						■

A	F	E	A	D	A	E	O	F	E	O	O	O	R	E	R
O	L	L	E	L	H	R	T	F	I	T	T	T	A	S	
R	O	W	S	T	L		E	H	L	N	W	D	H	O	
	S				S							E	M	Y	

Answer: All the flowers of all the tomorrows are in the seeds of today.

7-B THE PARTS OF A FLOWER. Bands 2 and 3

Introduction.

The general approach used here for learning the parts of a flower is to have the students tear apart various types of flowers, then learn the names and relationships of whichever obvious structures they find. This means if the students fail to find certain specialized structures, those structures remain unlearned. Since young students can't learn everything anyway, it seems reasonable to confine their arena of learning to those specifics they actually see.

The amount of material observed and learned will vary from class to class according to the types of flowers available. The teacher background notes near the end of this lesson try to cover the common possibilities so that a teacher may be able to select out those which are applicable to the given neighborhood and to the student ability level.

Materials.

-Hand lenses
-Small, sharp cutting tools
-Notebooks

Problem:

What kinds of parts and structures can you find in flowers?

Procedures in Brief.

1. Collect flowers, any and all kinds.

2. Dissect and identify parts.

3. Sketch and label some parts in notebooks.

Procedures in Detail.

1. Collect flowers to be dissected. These might be the same flowers which were collected for observation for the last topic.

   For the greatest degree of latitude, use whatever flowers are available, the more kinds, the better.

   For younger students, you may wish to eliminate some flowers with unusual structures which are hard to see or which involve anomolies hard to explain.

   For a very programmed lesson, each child can be given the same kind of flower to take apart so that everyone has the same parts to identify at the same time.

2. Dissect and identify.

Working either individually, or in pairs, the students can take apart each flower carefully, using any sharp cutting instrument as necessary. Have them spread the pieces out on a white sheet of paper, placing the parts on the paper in the same relative positions they had when the parts were in the flower. Examine the inner chambers of each flower with a hand lens.

After the flower parts are laid out and examined, you might begin the discussion by finding out how many parts the class can already name.

Next deal with parts they ask about.

Lastly comes drawing attention to and giving information concerning important remaining parts which they have not noticed.

How many parts are important depends on the age and ability of the students. Select as many as seems feasible from the teaching background information given below.

3. Sketch and label identified parts in notebooks.

Students sometimes like to press flowers. If this is done, have them use newspaper as the first layer of pressing material next to the flower. Newspaper absorbs the moisture well and at the same time protects the pages of books from being spoiled by damp flowers being put into them. Layers of newspaper topped by a flat board and put into a book press or under a heavy weight makes a good press. The newspapers should be changed after the first 24 hours, again a few days later, and again each week until the flower is dry. See any reference book devoted to techniques for preparing herbarium specimens.

References and Correlations.

The following recipe for making home-made perfume is copied from an old issue of the Honolulu Star Bulletin.

Recipe for your Own Perfume.

"Gather flowers with as little stalk as possible and put them into a jar filled with a bland oil like olive oil or sweet almond oil. Let flowers stand in oil for 24 hours to extract the fragrance.

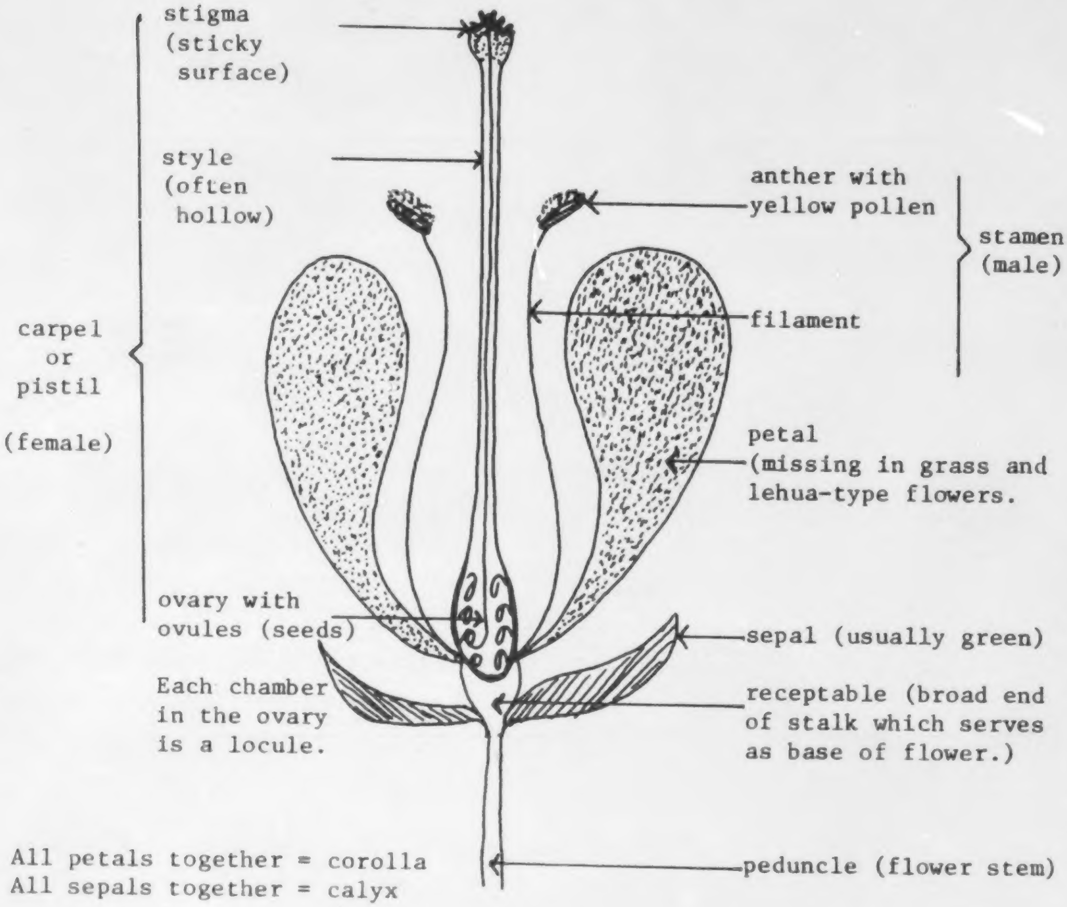
Then filter off blossoms through a coarse cloth, warming the fat slightly if you've used a solid one. Discard spent flowers and repeat the process with fresh blossoms three or four times, gradually increasing the strength of the perfume.

When you've reached the potency you like, mix the fragrant fat with an equal amount of 70 per cent ethanol rubbing alcohol. Put the fat-alcohol mix in a tightly closed bottle and shake vigorously. Let stand a day. Shake again daily. Repeat each day for a week."

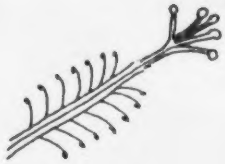
See hobby craft books for directions on preparing dried flowers in silica gel.

Teachers Background Information.

The following diagram is intended for a teacher's reference but it could be reproduced by a ditto process, or on the blackboard or overhead if this seems desirable. It gives more detail and terminology than may be needed for most classes.


stigma (sticky surface)
style (often hollow)
carpel or pistil (female)
ovary with ovules (seeds)
Each chamber in the ovary is a locule.
anther with yellow pollen
stamen (male)
filament
petal (missing in grass and lehua-type flowers.
sepal (usually green)
receptable (broad end of stalk which serves as base of flower.)
peduncle (flower stem)
All petals together = corolla
All sepals together = calyx

Below are notes to assist teachers with special flower structures and forms which commonly occur in Hawaii.



HIBISCUS. The numerous filaments are attached to the side of the COLUMN. The style is inside the column. The stigma is 5 parted.

DOUBLE HIBISCUS. The Common double pink hibiscus gives a clear example that extra petals are broadened filaments. In the double hibiscus, find the five normal outer petals. Toward the center, note the frills of double petals spreading away from the column. Often the double petal retains parts of the stamens from which it developed, attached to its midrib.

ORCHIDS. Orchids are monocots having 3 sepals and 3 petals with one petal broadened into the LIP. In the column, stamens are fused to the carpel.

PEAS AND BEANS. The uppermost of the 5 petals is big and broad and is called the BANNER. The two lower petals are folded together to form a KEEL inside of which are the stamens and pistils. The 10 stamens are often grouped 9 in one bunch and 1 by itself. The ovary very soon develops into a pod which can be seen if the keel is opened. Pea and bean flowers are bilaterally symmetrical.

WATER LILIES. The outer circle of sepals are green on the underside and petal-colored on the upper surface. The petals are a gradation from sepal-like to petal-like.

LILIES. Lilies are monocots and therefore have their parts in sets of 3's. The ovary is covered by the petals.

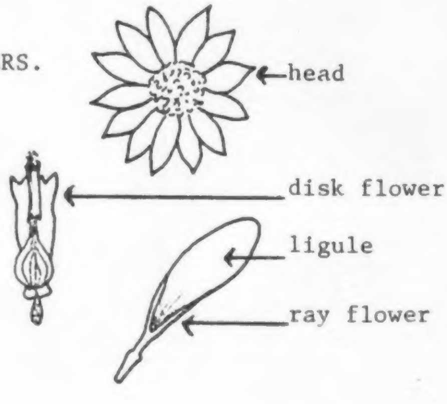
AMARYLLIS. Amaryllis are also monocots with parts in sets of 3's, but they have the ovary below the base of the petals.

HAOLE KOA, LEHUA, BOMBAX, have no petals. The puff-ball flower consists of a "feather duster" of stamens. Such flowers are called APETALOUS.

PEPPER TREES, SOME PAPAYA'S. The flowers on some plants have only pistils and no stamens. These are female. Other trees have flowers with stamens and no pistils. These are male. Papayas also have many intergrades of sex.

DAISIES, SUNFLOWERS, ASTERS, and ALL COMPOSITE FLOWERS.

The flower HEAD is a compact mass of many tiny flowers of two kinds.
The small tubular DISK FLOWERS are packed into the central area. They are pistillate female flowers.
The outer circle of RAY FLOWERS each have a LIGULE extending outward. They are staminate male flowers.

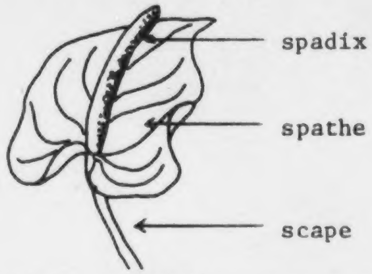


BOUGAINVILLEA. The three purple or red "petals" are colored leaves called the BRACTS. The flowers are the small white tubular shaped structures between the bracts.

POINSETTIA. The red "petals" are leaves called BRACTS. The flowers are the yellow knobs in the center of the circle of red bracts. The knobby flowers have thick "glands" with "mouth openings" on one side.

NASTURTIUM, VIOLET, and some other flowers. These have SPURS sticking out behind the flower. The spur is a deep indentation formed in a sepal, or sometimes by the petals, in which nectar is often cupped.

CALLY LILY, SPATHOSPHYLLUM, ANTHURIUM. The single white or colored bract is the SPATHE. It encloses the SPADIX which is a spike of tiny flowers without petals. The female flowers usually are on the lower half of the spadix with the male flowers above. The flower stem is the scape.



GRASSES. Grass flowers have no petals. The anthers and stigmas are protected by small bracts which the students may observe with the help of a hand lens. The parts of the grass flowers have an entirely different vocabulary. See any standard botany text for the rather complicated grass flower terminology.

Additional Problems for challenging individual students or groups.

1. Who can manage, by any means whatsoever, to keep a cut flower fresh for the longest time? So far, the record is 5 weeks for a lobster claw heleconia. Dried flowers are not eligible for the contest.

2. Using library references, find out the parts and names for grass flowers. Collect some grass flowers and glue their parts, with labels, onto a card. Teach your classmates the parts of a grass flower.

3. What is a BRACT? Find out and teach your classmates, giving examples. Bougainvillea and poinsettia are two easy examples to begin with.

4. What is flower nectar? How do bees get nectar from flowers? How do bees change nectar into honey? Which flowers do bees use to get nectar? Do they always visit the same flowers?

5. Flowers without petals are called APETALOUS meaning "no petals".

Haole koa and lehua are examples of apetalous flowers. Such flowers often have many stamens.

How many stamens can you count in various types of apetalous flowers? Does each species always have the same number of stamens?

6. The same kind (species) of flower usually always has the same number of petals and the same number of other parts.

Plumeria flowers usually have 5 petals. Have you ever seen a plumeria with 4 petals? (Such anomalies sometimes occur.)

What is the standard number of petals for other flowers which grow in your neighborhood?

THE NON-TREE

Decode the following cryptogram by substituting letters of the alphabet for those given. The same code letter always stands for the same alphabetical letter. If P represents U in one place, then P always stands for U wherever it occurs in this same puzzle. (Answer on page 68.)

X YXJXJX LOXJG TF JKG X GNVV. TG
SXF JK GNHJP. VXZS OVXW RNKDF
UTNVZGOA WNKI GSV HJUVNRNKHJU
ZKNI. GSV KJOA FGVI X YXJXJX
LOXJG SXF TF GSV KJV DSTZS
FHLLKNGF GSV YHJZS KW YXJXJXF.

Answer: A banana plant is not a tree. It has no trunk. Each leaf grows directly from the underground corm. The only stem a banana plant has is the one which supports the bunch of bananas.

7-C FLOWER ARRANGEMENT. Bands 2 and 3

Introduction.

The title refers to flower arrangement on the plant stem, not in a vase!

The vocabulary here is quite technical and not at all essential beyond what the students may enjoy learning. The chief value for young students of sorting out and grouping flowers according to their different arrangements is simply to heighten their observational attention.

Time Frame.

Probably one class period, or conversation during a field trip or botanical garden tour.

Materials.

-Neighborhood and home flowers with their stalks
-Notebooks

Problem:

How are flowers arranged on their stems?

Procedures.

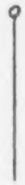
Any method at all which increases observational skills and teaches a few types of inflorescence is a good procedure for this lesson. Here is one mode.

1. Collect flowering branches and stalks.

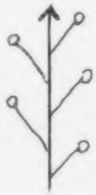
   Ask the students to bring in flowers which are grouped in bunches on the same stalk or along a branch. Some single flowers are also acceptable. You may wish to increase the collection to make sure of a variety of arrangements. To do this you could add flowering weeds which generally display a wide selection of different arrangements.

2. Make "shorthand" sketches of arrangements.

As shorthand symbols, a small circle represents a flower. A line represents a flower stem or a plant stalk. An arrow indicates a growing tip of a plant stem. At the left, #1 is a single flower on its stem. #2 is a group of flowers attached to a stem whose tip is green and continuing to grow.



#1



#2

Have the students make drawings to demonstrate the arrangement on the stalk made by the flower branches they have brought to school.

3. Learn names of arrangements which students diagrammed.

The names, for teachers reference, of some common flowering arrangements are given under Teacher's Background Information below. Not all of these need to be learned. Whichever arrangements the students have found among their branches might be the measure of which ones for them to learn.

The Band 3 students could be challenged to find some of the more difficult or complex arrangements.

4. Notebook Reports.

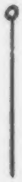
The notebooks might reflect the students observations along with their shorthand diagrams and names.

An alternate mode of handling this lesson might be to post on the bulletin board the diagrams of different arrangements and have the students look for actual flowers which demonstrate the given diagrams.

Teacher's Background Information.

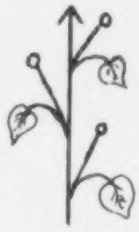
A single flower or a group of flowers on a plant is called its INFLORESCENCE.

A SOLITARY flower is one flower on one stem.

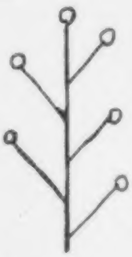


A TERMINAL flower grows at the tip of a stem, thereby ending further growth of that stem.

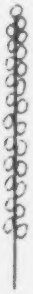
AXILLARY flowers grow in the leaf axils, while the tip of the stalk keeps on growing.



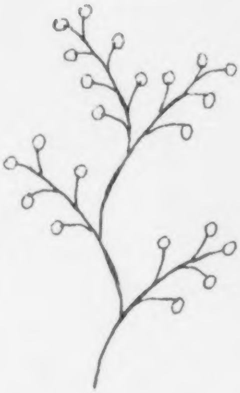
In a RACEME, flowers grow out from the side of a stalk. Each flower has its own stem.



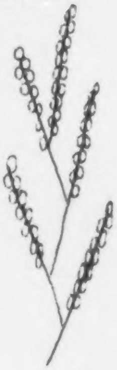
In a SPIKE, flowers are sessile on the central stalk. (Sessile - without stems.)



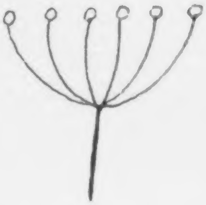
A PANICLE may be a group of racemes;



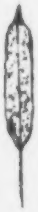
or a panicle may be a group of spikes.



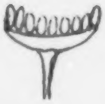
An UMBEL is a flat-topped cluster of flowers with all the flower stems attached to the stalk at the same spot.



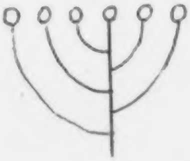
A CATKIN is a spike with very closely packed sessile leaves.



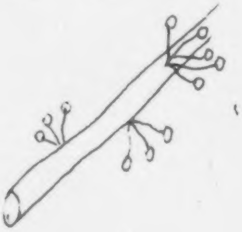
A HEAD is a group of sessile flowers packed onto a flat receptacle, as in a daisy.



A CORYMB is a flat-topped group of flowers, each on its own stem. The stems are attached to the stalk at different places.



CAULINE flowers grow from the side of a large tree branch, as in Shower or Mountain apple.



Making Little Ones out of Big Ones.

How many smaller words can you find in this one big word? (Do you know what the big word means?) The new words formed may have any number of letters but the letters must occur in the same order as they appear in the long word. For example, FORCE is one of the words. But SIN is not because it reverses the order of some letters. Proper names and plurals are not allowed. Our experts found 22 smaller words.

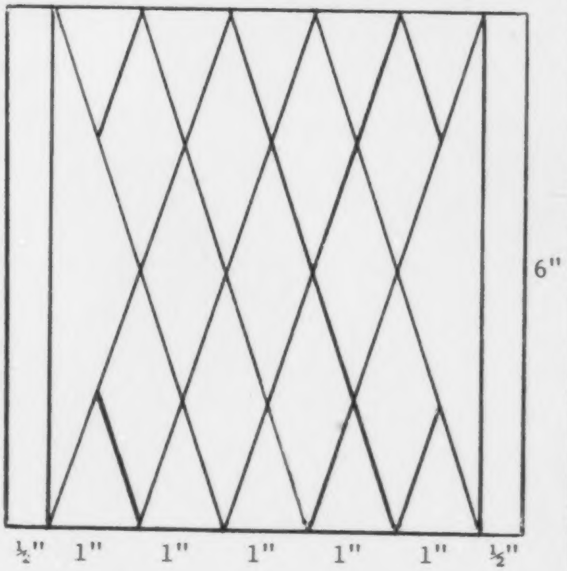
INFLORESCENCE

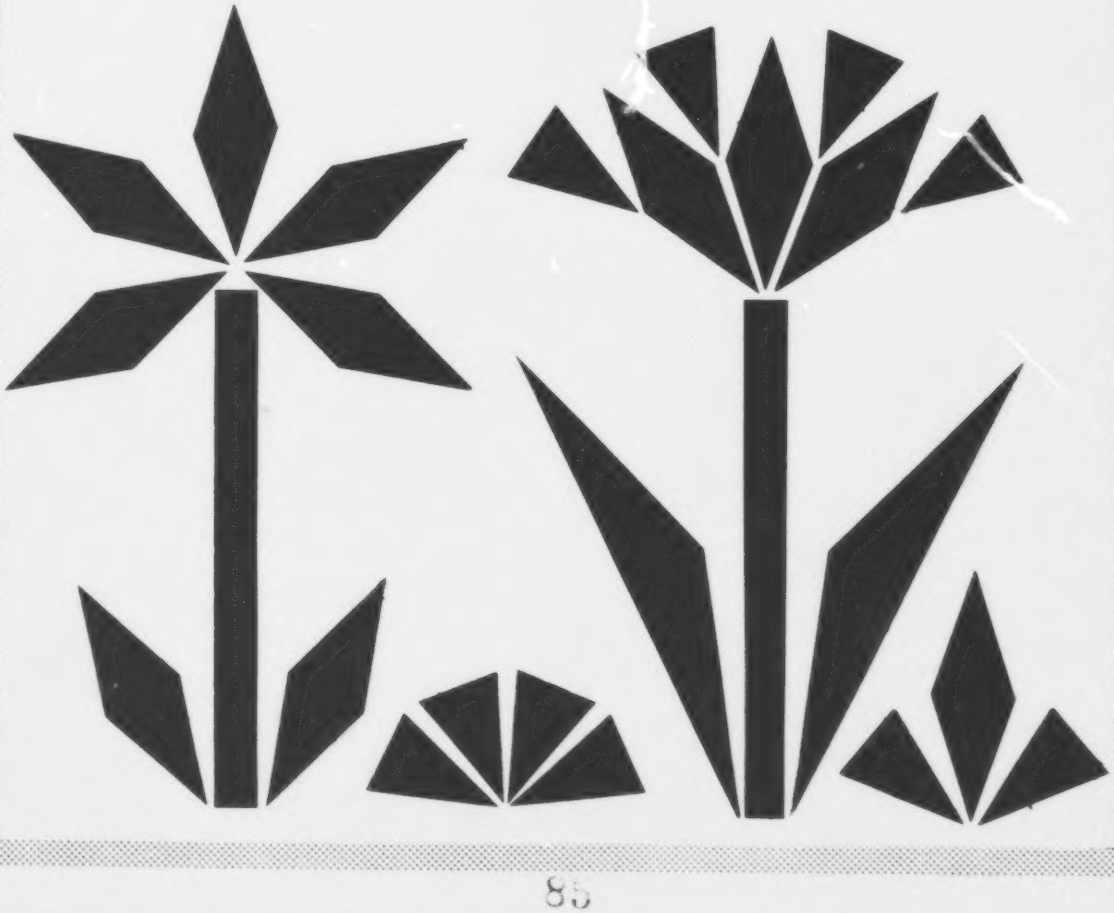
Puzzle #1

Cut the square into 25 pieces indicated by the lines. Use the pieces to build a flower garden. (Teachers note: A few possible designs are shown below. To make a larger puzzle, redraw the square using the measurements indicated along the sides of the square.)

Puzzle #2

Cut the flowers below into their 25 separate pieces. Assemble the pieces to form a perfect square.





8. FRUITS

Introduction.

A study of fruits is the next logical step in this Parts of Plants series. Fruits follow the flower in developmental sequence on the plant.

This exercise lightly calls student attention to the different types of fruits and their names. It provides further practice in observation and sorting techniques.

"Fruits" is divided into five sub-topics:

8-A FRUITS Band 1.

8-B STRUCTURES THAT COME AFTER THE FLOWER. Bands 2 and 3

8-C FLESHY FRUITS Bands 2 and 3

8-D DRY FRUITS Bands 2 and 3

8-E FRUITS, SPECIAL CASES. Band 3

8-A FRUITS. Band 1

Introduction.

This sub-topic gives a superficial coverage of FRUITS for primary children. Primary teachers who feel their classes can exceed the small amount of materials supplied here for Band 1 may wish to add a few concepts from the Band 2 and 3 activities.

Time Frame.

About ½ class period to collect specimens.
About 1 class period to dissect and discuss.

Materials.

-Fruits collected in the school neighborhood and/or brought from home.
-Instruments for opening the fruits (fingers, knives, nutcracker).
-Newspapers on which to work.
-Clean-up facilities.

Problem:

What different kinds of fruits do we have in our neighborhood?

Procedures in Brief.

1. Collect pods, beans, grass tassels, other fruits from the school neighborhood. Bring additional fruits from home.

2. Observe the external features of the fruits.

3. Take fruits apart in class and see what is inside.

4. Discuss the fruit in general but especially as a container for seeds.

Procedures in Detail.

1. As the teacher, make a preliminary survey of the neighborhood to locate ripe weeds and other fruits and decide to which areas to bring the class for observation.

   During class, take the children on a tour of the chosen area to collect "things that grow on plants, not counting leaves or flowers." This includes pods, beans, grass tassels, burs, stickers, capsules, nuts, round fruits, and whatever else is available. Avoid use of the term "fruits" until you can introduce it with its proper definition.

Ask the children to bring to school samples of things (other than leaves) which grow on plants in their home neighborhoods. You may wish to add a few fruits of your own choice to insure broad coverage.

When all the "things that grow on plants" are assembled from the class tour and from home, distribute them among the class for closer observation.

2. Observe external features.

Draw out from the children as many observations as possible. Note colors, sizes, shapes, textures, odors, stems, "bumps", "dimples", etc.

3. Dissect the fruits.

The assignment is: "What is inside your 'package'? Look and see." Give time for cutting and tearing open the collected materials and seeing what is inside.

4. Discussion.

Did everyone find seeds? number, size, hardness, color, shape . . .

What different coverings were observed? rinds, peelings, shells, dry skins . . .

Is the material around the seeds juicy or dry?

How many seeds were in one seed package? one? several? many? Is your seed package good to eat? Which parts can you eat? Other comments.

Vocabulary:

The "seed container" of a plant is called a FRUIT. A fruit is a plant's store house for seed.

Some seed packages are dry when ripe. They are called DRY FRUITS, e.g. pine cone, rice and wheat grains, some weed capsules.

Some seed packages are juicy when ripe. They are called FLESHY FRUITS, e.g. mango, watermelon, naupaka, banyan.

The word fruit has nothing to do with being good to eat. Some fruits are edible such as mango and wheat. Some are not, such as the beans on shower trees . . . Some fruits inedible to people are eaten by animals.

This Band 1 activity comes to an end when the young children have had an agreeable amount of exposure to different kinds of fruits and some vocabulary.

8-B STRUCTURES THAT COME AFTER THE FLOWER. Bands 2 and 3

Introduction.

This activity for older students introduces the term "fruit" in its technical sense and divides fruits into two categories: fleshy and dry.

The content and the approach is similar for both Bands. Band 2 students may reach only minimal vocabulary and observational levels while Band 3 students may be expected to delve into greater detail and produce more sophisticated notebook reports.

Please note that the word "fruit" is not used with the class until after several post-flowering structures have been examined and the term can be introduced in its botanical sense.

Time Frame.

One period (or a homework assignment) to gather structures to be examined.

Possibly one class period for dissection and discussion.

Materials.

-The pods, capsules, etc. collected from the weeds which were observed in Topic 6.
-Other fruits collected elsewhere.
-Cutting tools for dissecting the fruits.
-Newspapers on which to work.
-Cleaning-up facilities.
-Notebooks.

Problem:

What different kinds of things grow on plants, following the flower?

Procedures in Brief.

1. Collect pods, stickers, berries, etc. from the weeds which were tagged in the Bud to Seed activity and from other sources. Bring in additional fruits from home and market.

2. Examine the collected items, first externally, then inside. Look for evidence that these objects are developments from a flower. Vocabulary: FRUIT, DRY, FLESHY.

3. Sort the fruits into dry and fleshy kinds.

4. Notebook reports with diagrams and terms.

Procedures in Detail.

1. A review of the data collected in Topic 6, From Bud to Seeds, could help to clarify the problem.

   By this time, perhaps the class can do much of its own planning on how to collect, and what to observe, about the kinds of things which grow on plants after the flowers fall off.

   Places to find things to collect might include: revisiting of the plants which were tagged in the Topic 6 study; items which grow on plants in the neighborhood and in the students home yards; items from the fresh fruit and vegetable sections of the local market.

   If a student does not know whether or not an item grew on a plant as a follow-up of a flower, would the class agree that it could be brought to school anyway? Perhaps someone else might know if it is a post-flowering structure.

   To insure that the student collection includes a variety of types, you may need to add a few weed capsules, at least one fleshy fruit, and a few nuts. It will save some trouble if you eliminate seedless fruits from the collection until after definitions are established.

2. Examine the collected items.

   If the above collection of materials was done in a previous class, or as homework, then examination and observation of the collection falls at the beginning of a class period.

   First examine the external features: shape, size, color, odor, texture, external features, special characteristics.

   Can the students set up their own data tables for recording these observations?

   Before opening the fruits, ask if they show evidence that they grew on the plant following the flower. (The remains of the flower are visible on some fruits at the end opposite the stem.)

   Next, examine the inside of the collected items. There are two jobs to be done here.

   1. Look for evidence that this item developed from a flower;
   2. Observe as many things as possible about the inside structures.

   Give time for this investigation. Another data table could be constructed to record observations of internal characteristics of the different fruits.

   (The internal evidence that fruits are the development from a flower is the presence of seeds which were seen as small green ovules in the ovary of the flower. Not as evident to the students is the development of the flower ovary wall into the fleshy parts of the fruit.)

Vocabulary:

Objects which grow on plants following the flower are called FRUITS.

FRUITS are the developed ovaries of flowers and contain the seeds.

A FRUIT is a "baby sitter" for a seed.
A ripe grass tassel is a fruit. It contains the grass seed.
A nut is a fruit. It contains the seed which is the nut meat.
A weed pod is a fruit. It contains the seeds of the weed.
A pod is a fruit. It contains the beans which are the seeds.

(Later under Special Cases, we will come to fruits which are developed ovaries but which are sterile, i.e. seedless.)

The word "fruit" is used differently by different people:
To a scientist, a fruit is a developed ovary with seeds. It may be juicy or dry; it may be edible or inedible.
To a supermarket shopper, a fruit is a juicy object to be eaten.
To a literary artist, a fruit is a result of an action,as in the sentence: "The fruit of his labor was success."

3. Sorting.

The following approach gets across the point that sorting is a human, arbitrary process.

Ask the students to sort their collection of fruits into any categories of their choice. (They may make a variety of assortments such as edible, big, small, wet, dry, soft, hard, cultivated, wild, anything!)

When the sorting is complete, have the students explain the basis on which they made their assortment. There may be overlaps and conflicts. This difficulty points up the need to be precise in defining the categories, while at the same time recognizing that an array of natural objects seldom fits perfectly into a humanly devised system.

Give ample assurance on all sides that all the sorting systems they chose are valid. In fact, if they had been around at the right time, their sorting system could have been the one which got into the botany books. As it is, certain botanists got ahead of them and put their own sorting ideas into print. Now we are stuck with sorting fruits according to the system they devised. People all around the world follow the same standard sorting system developed by the early botanists. Thus we are able to communicate with one another clearly when we refer to certain fruits or parts of fruits.

The botanical system for sorting fruits is to divide them into two categories:

1. Those which ripen without a juicy pulp, called DRY FRUITS.
2. Those which ripen with a juicy pulp, called FLESHY FRUITS.

Ask the students to forfeit the use of their own perfectly good sorting systems in the interest of uniformity with the botanists, and arrange their collection of fruits into two piles.

Pile 1. DRY FRUITS.

Pile 2. FLESHY FRUITS

The time element may require a teacher decision at this point.

Alternative A.	Alternative B.
Go directly into sub-topic 8-C without a break. Do the work on fleshy fruits now while the fruits are still fresh and student hands are messy anyway. Save the dry fruits for examination on a later day.	Stop here. Clean up. Do the notebook reports on this topic. Put the fleshy fruits which will hold until tomorrow into one place. Perhaps further fresh specimens can be added at that time. Save the dry fruits for a later date.

Band 1 Puzzle

Directions: In the following words, every third letter is missing. Choose any letter of the alphabet to insert in the blanks. The completed words are fruits (as fruit is defined by botanists).

C O __ O N __ T

P I __ E A __ P L __

W A __ E R __ E L __ N

S T __ A W __ E R __ Y

P O __ E G __ A N __ T E

B R __ A D __ R U __ T

O R __ N G __

B E __ N

L E __ O N

P L __ M

G U __ V A

M U __ B E __ R Y

T O __ A T __

M A __ G O

S Q __ A S __

S O __ B E __ N

B A __ A N __

C O __ N

8-C FLESHY FRUITS. Bands 2 and 3

Introduction.

The consideration of fleshy fruits can be handled as a separate topic complete in itself; or it can be latched on to the previous sub-topic to save double clean-up work.

The content is the same for both Bands. The difference is in the degree of detail taken.

The chief concept and skill continue to be observation with some vocabulary building.

Materials.

-Fleshy fruits which were collected for the previous topic plus any desired additions.
-Cutting tools to use on the fruits.
-Newspaper on which to work.
-Clean-up facilities.
-Notebooks.

Problem:

What kinds of structures can we find in fleshy fruits?

Procedures in Brief.

1. Dissect fleshy fruits.
2. Learn the botanical terms for at least some of them.
3. Continue with diagrams and names of fruits in notebooks.

Procedures in Detail.

1. Dissect fleshy fruits.

   Ask the students to open and examine their fleshy fruits to see if they are "baby-sitting" any seeds.

   Take note of seed number, placement, size, color, hardness of the seeds.

   Look also for other structures and qualities such as rind, odor, taste, texture, etc.

2. Vocabulary: For vocabulary with diagrams, see below under Teacher's

Background Information. Select only those terms appropriate to your class.

There must be at least a dozen teaching methods for getting students to connect the different kinds of fruits with their names and definitions. Here are a few ways from which you might choose; or invent your own better way.

a. As students show their dissected and nicely arranged fruits and ask their names, tell them one by one; or

b. The teacher writes the name of a fruit type (drupe, berry, etc.) on the blackboard or overhead, and describes it. The students see which of their dissected fruits match up to these models; or

c. The teacher picks up one of the student's dissected fruits, explains to the class what type it is and gets some comments on its characteristics. The students see what other fruits they have which would fall into this same category; or

d. The teacher reads the botanical definition of a given fruit type. The students look over their dissected fruits to see if they have any which conform to the definition.

3. Notebooks.

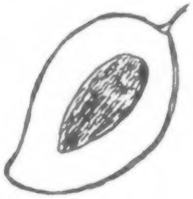
As the students identify and learn terms for their fruits, sketches and labels go into the notebook, along with those from the last sub-topic.

As a point of scientific honesty, a drawing is made from the dissected fruit being observed and in the way it is observed. To copy or trace a picture from a textbook or from these notes might be useful for vision testing or for learning how to hold a pencil but bears no relation to recording observations in science.

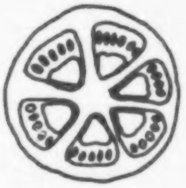
Teacher Background Information.

Since this is not a college botany class, it is strongly recommended that fruit types and names which are not found in the class collection, or not understood by the class, be skipped and made no more of. In this exercise, elementary children receive some exposure to the names and types of fleshy fruits which they have collected; and if they remember some of them it is sufficient.

A DRUPE is a fleshy fruit with a single hard stone in the center. e.g. avocado, mango, some palm fruits, cherry, plum, pepper tree fruits, pukiawe, sea grape, naupaka. A coconut is sometimes called a dry drupe. (It is dry when mature.)



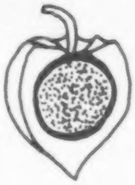
A BERRY is a fleshy fruit with many seeds embedded in its soft fleshy parts, e.g. tomato, grape, papaya, guava, watermelon, orange, cucumber, apple, and many others.



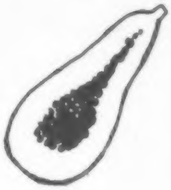
Some merriment and fun can sometimes be had over what botanists call berries. At this point the student's opinion of botanists usually drops to an all-time low. To make matters worse, strawberries and mulberries are not classed as berries!

Berries are of several types:

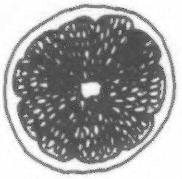
a. TRUE BERRIES. The seeds are scattered throughout the flesh, e.g. grapes, tomatoes, soursop, ohelo, breadfruit, starfruit, panini.



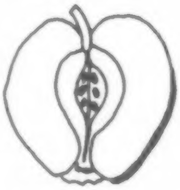
b. PEPOS. Berries with thin, tough skins; seeds in a hollow or pulpy center, e.g. pumpkin, papaya, cucumber, gourd, lilikoi, watermelon, cantaloupe, pickles.



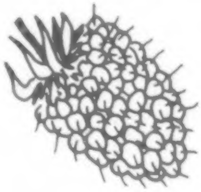
c. CITRUS or HESPERIDIUM. Tough skin; flesh divided into sections, with usually two seeds per section, e.g. orange, lemon, lime, pomelo, grapefruit.



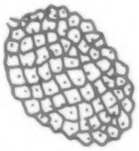
d. POME. Thin outer peeling; seeds in a soft core, e.g. apple, pear.



AN AGGREGATE fruit is a fruit which developed from a single flower, but that flower had many ovaries or carpels which became fused together as the walls developed, e.g. strawberry, mulberry, raspberry, blackberry.



A MULTIPLE fruit is the development of many individual fruits, each from its own separate flower. The many fruits sit close together in the same receptacle, e.g. pineapple, pandanus, monstera.



8-D DRY FRUITS. Bands 2 and 3

Introduction.

This sub-topic is the sequel to Fleshy Fruits. It follows essentially the same procedure of dissecting fruits and matching them as well as possible to their botanical definitions.

The teacher may wish to continue the same pattern of presentation used for fleshy fruits, or switch to a different approach.

The same standards apply that the actual fruits are the learning vehicle, not the teacher's notes.

Materials.

- *-Dry fruits which were collected in sub-topic 10-B plus any others desireable to add*
- *-Cutting tools to use on the fruits*
- *-Notebooks*

Problem:

What structures can we find in dry fruits?

Procedures in Brief.

1. Dissect dry fruits.
2. Learn some vocabulary for various types of dry fruits.
3. Continue in notebooks with diagrams and labels.

Procedures in Detail.

1. The dry fruits kept aside from sub-topic 8-B can now be brought out. Additional dry fruits might be added to the collection.
2. Before beginning dissection, look over the external features and characteristics.
3. Dissecting dry fruits often requires sharp knives or nutcrackers and some muscle.

   The seeds of dry fruits are often covered by several layers of tightly adhering coats. Look for these.
4. Vocabulary. See Teacher's Background Information below.

It is not necessary or important to find an example or to learn the name for every dry fruit shown in the Teacher's Background Notes.

3. Notebooks.

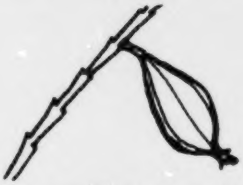
Honest diagrams and labels are to be made from observations, as before.

Teacher's Background Information.

Even the botanists have different ways of dividing the dry fruits into groups. One way is to separate them first into those kinds which open up by themselves as opposed to those which remain closed after the seeds are ripe.

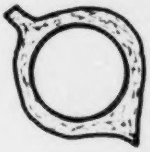
DEHISCENT fruits open up by themselves when the seeds are ripe. Some dehiscent fruits are:

Haole koa and most other bean-type pods.
Most capsules such as Bird-of-paradise, lily, amaryllis.
Capsules with elastic walls which spring open when ripe and shoot out their seeds such as balsam and castor bean.



orchid capsule

INDEHISCENT fruits stay closed even after the seeds are ripe. The young plant has to grow out through the covering. Nuts are indehiscent.

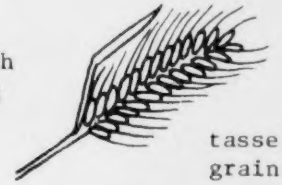


nut

Another way in which botanists divide dry fruits is according to the kinds of coverings over the seed or seeds.

A GRAIN is a small dry fruit produced by a grass. Each grain is protected by dry coverings and arranged along a spike. Some examples are:

wheat, rice, other cereal grains.

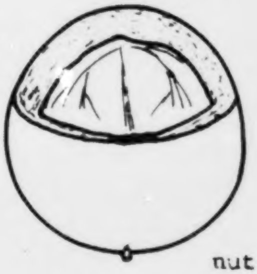


tassel of grain fruits

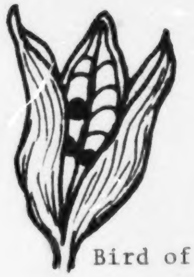
A NUT is a dry fruit which has:
- an outer spongy husk which is usually shed when the nut falls from the tree;
- a hard shell;
- soft "meat" inside.

The nut-meat is the seed. Some examples are:

kukui, macadamia.



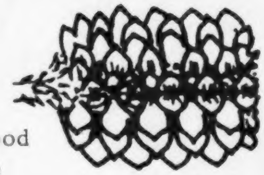
nut



Bird of Paradise capsule

A CAPSULE is a dry seed case which contains many seeds and usually splits open when ripe. Examples are:

lily, bird-of-paradise, poppy, orchid, amaryllis, hibiscus, eucalyptus, lipstick plant. Woodrose is a capsule which does not split open.



ironwood cone

A CONE is a seed container which holds seeds under its "flaps" until they are ripe. Then it opens. Examples are:

Ironwood, Norfolk and Cook pines. These are not cones of the same category as those on conifer trees in colder climates.

The names of some other types of dry fruits which are less common but which an ambitious student may care to look up are: achene, follicle, utricle, samara, silique.

TWENTY-TWO FRUITS

GOOD TO EAT

GROWN IN HAWAII

Look for them in both directions across, up and down, and diagonally.

```
S M A H Y D U R F D A E R B
T U N O C O C H S I H T O R
E L R T A R S A V A U G G A
A P G I F P O H A N T A N D
B A N A N A T L A Y A P A P
Y L I R P A A I A A A O M O
R W A T E R M E L O N S T S
R O L L B A O C H E D R C T
E M I L D W T S H T M U N E
B E T A C H O C K E N O T E
L R C I O K I L I L R S N W
U A H T S O L E M O P R O S
M T I E L P P A E N I P Y K
```

Answers. (Not to be copied on the students hand-outs.)

→
banana
watermelon
poha

←
guava
lilikoi
pineapple
papaya
breadfruit
coconut
pomelo
fig
lime

↓ litchi

↑
sweetsop
soursop
tomato
plum
mulberry
mango

surinam cherry ↘
lemon

macadamia nut ↗

8-E FRUITS, SPECIAL CASES. Band 3

Introduction.

The students have now been exposed to a number of categories and definitions which scientists give to fruits. Fruits, like all living things, persistently fail to fit precisely into the categories defined by scientists. Furthermore, Hawaii has more than its share of special cases.

This sub-topic is presented in different format. There are no listed materials or procedures. Rather, special cases of fruits are written up as Teacher Background Information. Each case is different and has different potential for use with a class. Problems and observations interesting at different student levels may be invented based on the information given.

One popular activity is to enjoy eating the edible fruits in class, giving attention to their flavors and fragrances.

Pineapple.

Pineapple is a multiple fruit. Each "eye" is a berry developed from the ovary of one flower. The developing ovary walls of each fruit become merged with one another and with the core or stem in the center of the fruit.

Pineapple flowers, and consequently the fruits, are set in spirals around the core. Page 52 describes how the spirals of the pineapple can be given higher visibility by winding them with colored threads.

Commercially grown pineapple is seedless because the flowers are not pollinated. In many plants, unpollinated flowers do not mature into fruit. Unfertilized pineapple flowers do mature into full fruits but seeds do not develop. Can the students find tiny black dots behind each "eye" which are the undeveloped seeds?

The pollinator of pineapple is the hummingbird. Hummingbirds are outlawed from importation into Hawaii because if they fertilized the pineapple, seeds would develop. This would greatly downgrade the commercial quality of the fruit as well as cause endless problems in processing.

Some pineapples are pollinated artificially at the Pineapple Research Experiment Station in Mililani so that improved hybrid fruits can be developed. The Hawaiian pineapple hybrids have been bred and developed to a very superior quality and size.

Many close relatives of the pineapple and some wild pineapple ancestors can be seen in the Pineapple Variety Garden on Kam Highway north of Wahiawa as well as at the Pineapple Research Experiment Station near Mililani.

For an elementary school presentation with colored pictures about pineapple and pineapple harvesting, see Exploring Nature in Hawaii, Book V.

A worthwhile field trip is participation in one of the regularly conducted tours through the Dole Pineapple Cannery at 650 Iwelei Road in Honolulu.

Banana.

The origin of the seedless eating banana is lost in antiquity. We do not know who developed the first seedless banana but somebody did since the eating banana is dependent on man for its reproduction. It has permanently lost its ability to set viable seed. The tiny black specks in ripe bananas are all the evidence of seeds which remain.

Peel a ripe banana. Gently squeeze the peeled fruit up and down its length and on all sides. Soon it will separate into three lengthwise wedges, corresponding to the three carpels of the flower, exposing the rows of black specks which would have been seeds.

Wild bananas and flowering bananas have seeds. A few of the seed bananas can be found in Hawaii. If anyone can get one of these, the rows of seeds can be examined in the fruit. Tiny, immature bananas can be seen under the bracts in the flower.

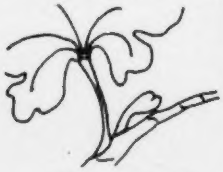
Figs.

Figs are one of the most common fruit in Hawaii. We have the edible fig eaten at table, creeping fig vines, which sometimes bear fruit, covering many walls, and many varieties of banyan trees. All banyan trees are fig trees and bear many small fig fruits.

Some of your brighter, older students might be sent on the wild goose chase of looking for an opened fig flower. There is no such thing so you can afford to offer them a bonanza for success in finding one. Then be prepared to pay up if they discover that the fig flower never opens and how it does function.

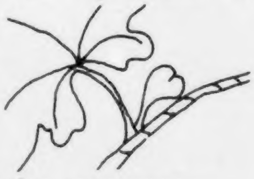
In the case of the fig, which includes all banyans:

The fig bud is



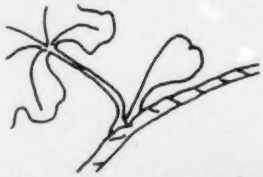
a tiny, green sphere with a tiny spot at the outer end.

The fig flower is



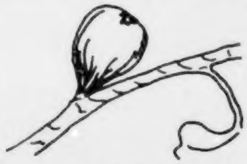
the same green sphere but larger, with a tiny hole at the outer end.

The young fruit is



the same green sphere but larger, with a tiny hole at the outer end.

The ripe fruit is



the same sphere but softer and slightly colored with a tiny hole at the outer end.

Cut cross sections of the fig at different stages of development. The stamens and pistils of the multiple flowers (no petals) extend from the inner wall toward the hollow center. The flowers are fertilized by a tiny fig wasp which enters through the hole at the tip end of the flower. As the wasp crawls around, it distributes the pollen from one place to another. The multiple fruits develop and ripen in the lining of the hollow sphere, yielding a sweet, fleshy ovary wall or fig.

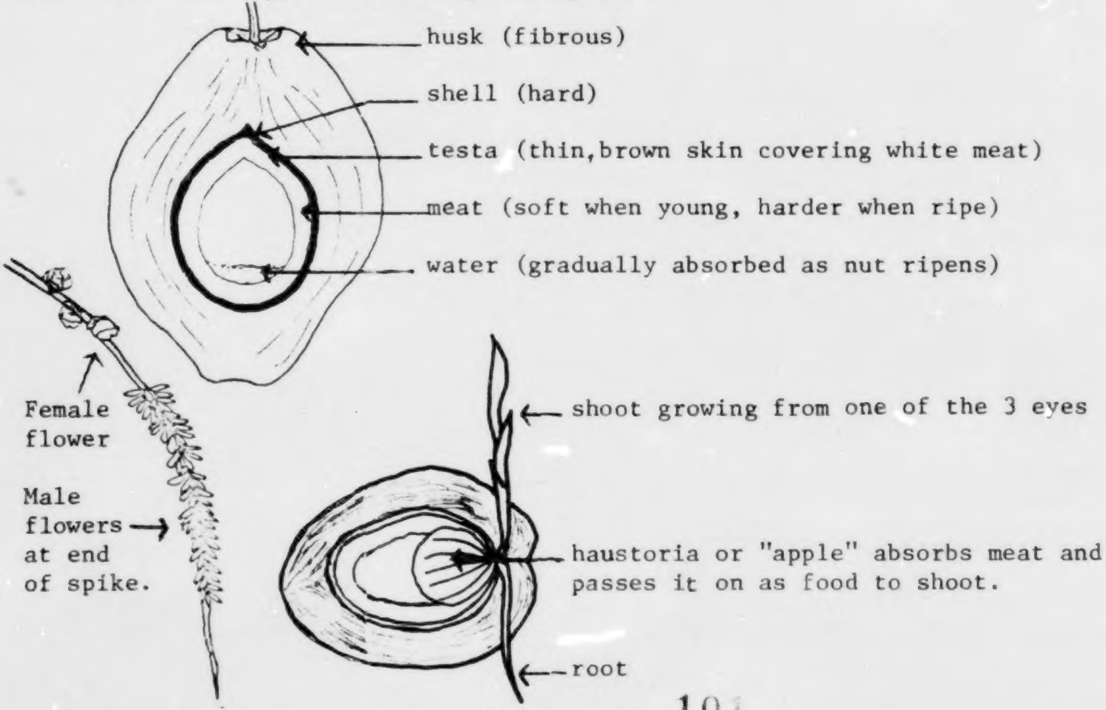
Compare the fruits of the commercial fig, the creeping fig vine grown on walls, and the banyan. Banyan figs are edible if you are starving to death. Try some.

Banyan seeds are distributed by birds who eat the ripe fruit. The birds do a good job of distribution judging by the number of banyan seedlings growing out of crevices in walls and sidewalks.

Coconut.

If you go to a neighborhood where the coconut tree trimmers are at work, you can collect coconuts at all stages of development from flower to ripe fruit. A walk along a beach or stream may yield coconuts at the beginning sprouting stage.

Line up a row of coconuts of all sizes starting with small "buttons" from flowering branches, to small green, to large green, to ripe, and finally to sprouting nuts. Open coconuts at all these stages of development and compare the textures, hardness, color, moistness, of the husk, the shell, the meat. Taste the meat and the water at different stages of ripeness. Don't miss the "apple" in the sprouting nut.


husk (fibrous)
shell (hard)
testa (thin,brown skin covering white meat)
meat (soft when young, harder when ripe)
water (gradually absorbed as nut ripens)
Female flower
Male flowers at end of spike.
shoot growing from one of the 3 eyes
haustoria or "apple" absorbs meat and passes it on as food to shoot.
root

Can you husk a coconut in less than one minute? Some people can.

Do you know how to crack a husked coconut into two halves with one blow, making a clean, even break around the nut? It can be done if you know where and how to hit the nut.

Have you ever shredded fresh, ripe coconut meat or squeezed out coconut milk? If so, it is only one step further to making coconut candy or coconut cake frosting.

Naval Orange, Seedless Grapes, Other Seedless Table Fruits.

For the most part, seedless fruits are the result of efforts by fruit growers within the last 100 years. Since the fruits are seedless, the plant then becomes dependent upon man for propagation by cutting or other forms of multiplication and transplant. The advantage is an improved table fruit commanding a higher market value.

Allamanda.

The small-flowered variety of Allamanda yields spiney capsules with viable, winged seeds. The large-flowered Allamanda cathartica Hendersonii sets no fruit in Hawaii, and evidently not in most other parts of the world. One seed pod with sterile seeds was located some years ago in its native Brazil. This brings up the interesting possibility, even probability, that all Allamandas, at least in Hawaii, are one clone, i.e. all the separate bushes are parts of the very same one individual plant propagated vegetatively and carried from place to place.

Native and Exotic Fruits of Hawaii.

The following questions could lead to several useful student "research" projects.

Which fruits were here in Hawaii before the Hawaiians came?

Which fruits were here in Hawaii before any Caucasians came?

Which are the favorite fruits of the various ethnic cultures in Hawaii?

Which are your favorite fruits grown in Hawaii? Not grown in Hawaii?

How, when, and from what country, did some of the fruits we have in Hawaii come?

The first litchi tree in Hawaii was brought by the Chinese and still grows in the parking lot of the Chun Hoon market on Nuuanu Avenue. That tree is the "mother" of all the litchis in Hawaii of that species.

The first kiawe or algaroba tree (which yielded beans for cattle fodder) was planted in a garden next to the Catholic Cathedral on Fort Street. The original stump is preserved with a plaque next to the statue of Our Lady of Peace in what is now a parking lot.

Some other "firsts" in Hawaii are found in Foster Gardens and at Lyon Arboretum. The "double coconut" in Foster Gardens holds the world record for longest maturing time. It takes 10 years to mature from flower to ripe fruit.

Castor Beans.

The attractive castor bean plant has interesting self-exploding fruits and beautiful seeds. The seeds are lethally poisonous and need to be handled with care, followed by thorough washing of hands. Persons with open cuts and blisters should not handle the seeds at all.

Using the proper precautions, hang up a cluster of castor bean capsules which are approaching the ripe stage in the classroom. From time to time, the students (and teacher) will be "shot at" by a ripe bean. This is not a good project to pursue at home where crawling babies might pick up and eat the expelled poisonous seeds.

Examine the nature of the elastic tissue in the ripening capsules. The seed pods of the lady slipper balsam flowers also explode when ripe.

Fruits and Art.

Dry fruits on their stems can be arranged as a dry bouquet.

Dry fruits can be pinned to burlap and made into a collage or mural.

Ironwood cones can be wound with yellow thread and transformed into tiny "pineapples" for corsages and favors.

Palm nuts, kukui nuts, and some others can be polished as costume jewelry.

Leis are made from numerous seeds and seed pods.

The fibers in the ripe Hala fruit were used by the Hawaiians as brushes.

Fresh Hawaiian fruits can be served in many artistic ways. Do you know how to make a pineapple boat filled with fresh fruit slices? Can you cut a mango into cubes which remain attached to the inverted skin?

Who can write a song about a Hawaiian fruit and sing it, or play it, for the class? If no one is good at writing music, write lyrics for a tune which already exists. Here is an example to the tune of "I don't like shoes upon my feet."

I like green mangoes from a tree
And rice and poi and sashimi.
I'll even eat a panini.
That's the Hawaiian in me.

9. VEGETABLES

Introduction.

A consideration of vegetables as plant parts and as foods are not on center target in the study of Parts of Plants. However it is important from the viewpoint of appreciation and understanding of our daily lives to know something about the parts of plants which we eat.

In the urban milieu in which most of our students grow up, the green groceries in the kitchen are so many steps removed from the farm that children inadvertently settle for the impression that peas come in cans, dried beans arrive in bags, and other fresh vegetables originate as cellophane-wrapped packets on supermarket counters.

Because of the nomenclature discrepancies between botanical and market terms, this discussion can further assist with the realization that classification systems are arbitrary and man-made. The use of one sorting system rather than another is a human decision not inherent to the articles being classified. It makes no difference to the flavor or functioning of a tomato that it is classified as a fruit by botanists and as a vegetable by chefs.

"Vegetables" is divided into:

9-A VEGETABLES. Band 1

9-[illegible] VEGETABLES. Bands 2 and 3

9-C SPICES AND OTHER MISCELLANEA. Band 3

9-A VEGETABLES. Band 1

Introduction.

The chief aim here in Band 1 is to impart to youngsters a realization of what some of the things are that they are eating, together with some appreciation of the contribution of plants to their diets.

Materials.

-*Vegetables; pictures of vegetables.*

Problem:

What are the names of some of the vegetables we eat?

What parts of plants do they come from?

Procedures in Brief.

1. Secure some vegetables or pictures of vegetables.
2. Learn their names, what parts of plants they are, their use as foods.

Procedures in Detail.

1. Secure vegetables.

   If a shopping center or market happens to be within easy walking distance to the school, it may be possible to arrange with the store manager to have a class tour of the vegetable section while both teacher and store manager assist the children in seeing the different vegetables and noting their names and kinds; or

   Ask students to accompany their parents on the next family weekend shopping tour to a food market. While the parents shop, the children can survey the vegetable counters. The vegetables seen there can be reported in class on Monday; or

   Arrange with a few class mothers to bring some fresh vegetables of various kinds to class on a given day; or

   For several days preceding the class, collect food store advertisements from the newspapers and from copies of homemaking magazines and seed catalogs which show pictures of vegetables. These can be used for making bulletin board arrangements of vegetables according to their kinds; or

   You may have an idea which better suits your situation.

2. When vegetables (preferably), or pictures of vegetables (if necessary), have been obtained by whatever method, discuss with the class their names,

and what parts of plants they are. Consider whether each vegetable consists of leaves, roots, fruits, or stems.

What is the appearance of the entire plant from which the vegetable was taken?

This topic gives an opportunity to learn about the many Oriental vegetables in use. These are often omitted from Mainland textbooks and seed catalogs, yet they are an important part of life in Hawaii.

Correlations.

The discussion on vegetables could continue into a health or nutrition lesson.

This class could be correlated with social studies in considering the various different cultural preferences for different kinds of vegetables.

TWENTY SEVEN SUPERMARKET VEGETABLES

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A S P A R A G U S T O W T
C T S L Y E L S R A P A O
U A Q G H C A N I P S T R
C O U P O T A T O D R E R
U R A L S O M O S H A R A
M A S B I A A M T S G C C
B T H N P F Y A E I A H O
E C U T T E L T E D B E R
R H U B A R B O B A A S N
Y E G A B B A C W R T T B
T S D R A L L O C E U N E
S E K O H C I T R A R U A
S N E E R G P I N R U T N
B A M B O O S H O O T S S
O N I O N O N O R A T A R
```

← 8 leaf vegetables

→ 5 stems or leaf-stems

↑ 6 root vegetables

↓ 6 fruits used as vegetables

diagonal = 1 flower vegetable

9-B VEGETABLES. Bands 2 and 3

Introduction.

This exercise emphasizes recognition of the vegetables we eat as parts of plants. As previously, the Band 2 and 3 materials are grouped together, the content for both Bands being similar. The difference lies in the level of sophistication at which the younger and older students work.

Time Frame.

Probably two class periods separated by time for observation of market vegetables.

Materials.

-Market or home grown vegetables.

Problem:

What is a vegetable?

Procedures in Brief.

1. Stir up a discussion over what a vegetable is.
2. Plan with the students how to find out what a vegetable is and what kinds there are.
3. Discuss the data or results of the investigation.
4. Notebook reports.

Procedures in Detail.

1. A controversy may have already been started during the last topic when the botanical classification of fruits was considered. If not, stir one up by questions similar to the following, or other questions you might think of.

   Is a tomato a fruit or a vegetable?
   Are carrots vegetables or roots?
   Is a raisin a vegetable? Is it a fruit?
   Is a pickle a vegetable? If not, what is it?
   Could a flower ever be a vegetable?
   WHAT IS A VEGETABLE?

2. Plan with the students how to find out what a vegetable is and what kinds there are.

The students will have their own various opinions on what a vegetable is. Lack of adequate information or of disagreement among them improves the potential for setting up an experiment for finding out.

One way to find out is to consult a dictionary. This method has its limitations. It yields little on kinds of vegetables or answers to some of the issues noted below.

Another way to find out is to go to the supermarket and see what is being sold as vegetables.

If the supermarket route is chosen, there are further problems to decide:

Will the data be gathered by individuals or by teams of students?
Will only fresh vegetables be considered or do canned vegetables count?
Will data be gathered on types of vegetables, names of vegetables, parts of plants the vegetable was taken from?
Is there interest in the appearance of the total plant from which the vegetable part was taken?
Will only vegetables grown in Hawaii be considered; those used in Hawaii; those used throughout the United States; or those used throughout the world?
What type of data sheet needs to be set up to gather the kinds of information decided upon?

Other ways to approach this topic might include a visit to a farm, or the visit of a farmer to the class.

3. Discuss the data.

The discussion will have to depend upon the type of investigation chosen and the kinds of data collected. As a minimum, it is hoped that at least the parts of plants from which vegetables come can be clarified.

4. Notebook reports will necessarily be of the informal type.

Correlations.

The conversation begun as discussion of what a vegetable is could go on to discussion of the taste of vegetables, favorite (and unfavorite) vegetables nutrition value of vegetables, preparation of vegetables, how vegetables are grown, how they are harvested, what cultural differences in Hawaii are evidenced by the types and preparation of vegetables.

A history-geography lesson could grow out of consideration of the origin of vegetables. For example, before Columbus, Europe had never heard of the white potato, the tomato, and corn (maize), as well as pineapple and tobacco.

What vegetables did the early Hawaiians eat?

Teacher Background Information.

The word vegetable is used to mean different things, depending upon who is using the term.

In the culinary sense:

Vegetables are plants or parts of plants which are good to eat.

Vegetables are eaten raw or cooked. If they are cooked, they usually retain their identity as parts of plants. When plant parts are processed so that they lose this identity we usually stop calling them vegetables. For example, tapioca, noodles, pepper, flour, cold cereal, are all made from plant parts but since they have lost their identity as plant parts we do not usually call them vegetables.

Vegetables may be any edible part of a plant: root (beet, carrot); leaves (spinach, taro leaves); leaf-stems (celery, rhubarb); fruit (squash); seeds (beans, peas); stems with flower buds (broccoli, cauliflower).

If what botanists call a fruit is served with a meat course, chefs call it a vegetable (squash, green pepper, green beans, peas, corn-on-the-cob).

If what botanists call a fruit is served as a side dish with lettuce, chefs call it a salad, e.g. tomato, avocado.

If what botanists call a fruit is served as an appetizer or as dessert, both botanists and chefs call it fruit. e.g. pineapple, papaya, mango.

In the botanical sense:

The word vegetable is not much used by botanists. Vegetation is used to mean green growing plants in general, whether they are good to eat or not.

In general conversation:

The word vegetable is sometimes taken in a very broad sense to include all non-animal living things that now grow or ever did grow. For example, in the game in which items have to be identified as "vegetable, animal, or mineral", the vegetable category includes all living plants and plant products such as chewing gum, sugar, many drugs, lumber, paper. The grouping becomes fuzzy in dealing with plant products farther removed from their plant origin. Coal, petroleum, natural gas, turpentine , alcohol, and the oxygen in the air come from green plants; but they are popularly called mineral rather than vegetable.

Table 1. Supermarket Vegetables Sorted According to Botanical Categories

LEAVES	STEMS	ROOTS	FLOWERS	FRUITS	OTHER
spinach taro lettuce (many kinds) cabbage (many kinds) watercress parsley Brussels sprouts collard greens turnip greens taro greens seaweed	onions potatoes (white) asparagus watercress bamboo shoots bean sprouts taro water chestnuts LEAF-STEMS celery scallions rhubarb	sweet potatoes yams carrots beets turnips rutabagas radishes gobo	cauliflower broccoli artichokes	tomatoes squash (many kinds) cucumbers (and pickles) peas in pod string-beans corn green peppers egg plant	mushrooms truffles

This list is deficient in the listing of Oriental vegetables. Adding these might make an interesting class project.

A FRUIT-VEGETABLE CRYPTOGRAM

Decode the following by substituting letters of the alphabet for those given. The same code letter always stands for the same alphabetical letter. If P represents U in one place, the P always stands for U wherever it occurs in this same puzzle.

ZSQJXX DTZ MFAJ F GTYFSNXY FY

YMJ INSSJW YFGQJ YT IJKJSI DTZ,

ITS'Y HFQQ XQNHJI YTRFYT TS

QJYYZHJ F KWZNY XFQFI. F YTRFYT

NX F GJWWD YT F GTYFSNXY.

Code: (Not to be reproduced on the student copies) Each letter of the alphabet is displaced 6 positions in alphabetical order. F = A, G = B, H = C, I = D, J = E, K = F, L = G, M = H, N = I, etc.

9-C SPICES AND OTHER MISCELLANEA. Band 3

Introduction.

The following few headings are not developed in standard format with suggested materials and procedures. These are rather "off-the-record" interest topics which can be pursued ad libitum.

A few questions and suggestions are included under each heading. Needless to say, Spices and Other Miscellanea are not vital to the study of plants.

What is a Spice?

What is a Spice? could be generated into a lesson similar to "What is a Vegetable?"

A variation might be to ask the students to pretend they are spice merchants in the days of Columbus. Where in the world (what countries) would they go to find spices and what parts of plants or what minerals would they look for? This gives some correlation with geography and history.

Following is a partial data table on spices for use as a teachers' reference.

Table 2. Spices and Flavors and the Parts of Plants from which they come

LEAVES	ROOTS	FRUITS	SEEDS	STEMS	FLOWER BUDS	OTHER
chives oregano mint thyme bay leaves allspice rosemary sage tarragon tea spearmint marjoram horehound	horseradish arrow root licorice tumeric	citron chocolate vanilla chilipeppers red pepper black pepper paprika nutmeg cardamon	celery seed cumin sesame mustard anise poppy fennel dill coffee caraway mace	cinnamon dill garlic ginger	cloves	salt (mineral) Aji-no-moto (monosodium glutamate) meat tenderizer (papaya juice) curry (mixture of tumeric and other spices)

Saps and oils of many of the above are extracted from leaves or from the entire plant, e.g. oil of wintergreen, oil of cloves.

Processed Plants which we Eat.

Another challenge which can be pursued is to find out what plants or plant parts are the source of some of our common processed foods.

A few examples, which can become an almost endless list, include:

Tapioca, from the root of the cassava plant;

Sugar, from cane or sugar beets or maple trees,
Flour, from grains of wheat,
Chocolate, from the seeds of the cacao tree,
Agar, from sea weed,
Alcoholic beverages, from fermented fruits and other plant parts.
Non-alcoholic beverages, such as cola, tea, coffee, fruit drinks, and so on.

Gifts to Us from Plants.

Some students may be interested in doing a project about all the non-food benefits which come to us from plants. Below are a few to give a start.

Lumber, from trees.
Paper, from trees.
Fossil fuels, from plants of the carboniferous era. This includes coal, petroleum, natural gas, and all their derivatives such as gasoline, motor oil, asphalt, tar, vaseline, grease, some waxes.
The oxygen in the atmosphere, from plant photosynthesis.
Chewing gum, from a tree sap.
Rubber, from latex of trees.
Cotton, linen, hemp, from plant fibers.
Numerous medicines and drugs, castor beans, mushrooms, poppies, many others.
Some strong poisons, sap of oleander, jatropha, bestill, datura, others.
Cosmetic oils, lotions, and perfumes, witch hazel, palm oil, olive oil, flower nectars.

Fun Arithmetic

	Answers		
Start with 50			50
Add the number of petals in a single hibiscus	+5	=	55
Multiply by the number of leaves per node in oleander	x3	=	165
Subtract the number of seeds in an avocado	-1	=	164
Divide by the number of legs on a lizard	÷4	=	41
Subtract the number of petal-like parts in an orchid.	-6	=	35
Add the number of wings on a butterfly	+4	=	39
Divide by the number of feet in 1 yard	÷3	=	13

The answer is a number which some people consider unlucky when it falls on a Friday.

Advice for Band 3 Students Going Into Junior High School

Directions: From the definitions, fill in the words next to the definitions. Transfer the letters from these words to the matching numbers in the sentence below. Work back and forth in both directions. When a word in the sentence becomes apparent, transfer its letters up to the same numbers in the words above. After you work out the sentence, think about what it might mean.

10 3 31 45 8 15 25 17 19 28 21 42 40	Shrub named for the insect which is the subject of this puzzle.
30 15 14 33 16 14 15 39	Usually a small, lacy plant. In the Ohia forest they grow up into this kind of tree.
36 47 4 49 24 11 46	A falling fruit from one of these trees could bash your head in.
7 5 28 27 42 10 15 8 23 12 32	Very tiny, white flowers often used in bridal bouquets.
1 26 9 6 43 18 17 41 24 48	Greenish, fragrant flower. (The first half of the name is repeated as the second half.)
40 37 6 44 32 2 39 38	Lavendar orchid often planted to hang in sprays from opened coconut husks.
22 15 35 13 20 24	Common hedge with many-colored leaves.
42 29 48 5 15 34 9 39 33	Basis of the "sweet industry" in Hawaii.

1 2 3   4 5 6   7 8   9   10 11 12 13 14 15 16 17 18.

19 20 21   22 23 24   25 26 27.   28 29 30   31 32 33

34 35 36 37 38 39   40 41 42   43 44 45   46 47   48 49.

Answer: You can be a butterfly. You can fly. But the cocoon has got to go.

10. SEEDS

Seeds is the concluding topic of the Parts of Plants series.

The study of the structure of seeds can be made more interesting if "Seed Germination", detailed in MORE PLANTS, is taken at the same time. In that way the action of the seed can be combined with the learning of its parts.

For this topic, as for the other topics of this series, only the gross anatomy of the seed is considered without concern for parts visible only under the microscope. A hand lens, however, can be a great aid.

"Seeds" is divided into four sub-topics:

10-A STRUCTURE OF SEEDS. Band 1

10-B SEED DISTRIBUTION. Band 3

10-C THE EXTERNAL FEATURES OF SEEDS. Bands 2 and 3

10-D THE INTERNAL ANATOMY OF SEEDS. Bands 2 and 3

10-A STRUCTURE OF SEEDS. Band 1

Introduction.

Teachers of primary children may make use of this superficial approach, or borrow parts of the Band 2 activities from Sub-topics C and D.

Time Frame.

Probably one class period.

Materials.

-Large seeds
-Hand lenses (optional)

Problem:

What is in a seed?

Procedures.

1. Soak some beans (lima, navy, pinto, other) for a few hours to soften the seed coat and the cotyledons.

2. Distribute the soaked seeds to the children, along with paper towels or newspapers on which to work. A hand lens may be provided.

3. The assignment is to ask the children to find out what parts are in a bean.

4. Vocabulary and discussion.

   A SEED is an object which contains a baby plant. In some seeds the baby plant is too small to see. In that case how could we find out whether it is there? (Use a "big" microscope; plant the seed and see if a plant grows out.)

   What other kinds of seeds, besides beans, do you know?
   What is the biggest seed you have ever seen? (coconut)
   What is the smallest seed you have ever seen? (probably orchid)
   Have you ever seen the baby plant between the two halves of a peanut?

5. Draw the picture of your bean seed:

   a. As a whole.

   b. Showing its parts.

10-B SEED DISTRIBUTION. Band 3

Introduction.

Seed distribution may be taught in the same style as previous topics in this series, namely by collecting samples, observing, and reporting; but if you have an imaginative class of bright and creative children you may wish to try the approach described here, or some modification of it, as a variation to the usual teaching pattern.

This activity is designated for Band 3 students but it could be tried with younger children.

Time Frame.

Part of one period to introduce the game.
A lapse of time, perhaps a week, to carry out the work.
One or two periods to present the inventions and find matching seeds.

Materials.

-Students provide their own as needed for their inventions.

Problem:

How can seeds move from place to place?

Procedures in Brief.

1. Discuss with students why seeds need to be distributed beyond their point of origin.

2. Challenge the students to invent a system whereby a seed could get some distance away from its parent plant. Have them make models of their inventions.

3. Hold a "Public Fair" of inventions and devices.

4. Find seeds which seem to have utilized the students' suggestions for transportation.

Procedures in Detail.

1. Discuss with the students the basic problem which seeds have for spatial distribution. The following italicized ideas are not to be read aloud to the students. That would be deadly dull. But the paragraphs may serve to give you an idea for making a presentation of your own.

Rooted plants stay in one place. They do not move by themselves. Can you imagine what would happen if all the seeds produced by one plant stayed right where they are produced and grew there? .(Responses: When they grew up they would choke one another. The plant would not be able to spread to a new location).

Since rooted plants do not move from place to place, how can plants be spread? (People transplant them. Their seeds are transported from the parent plant to some more distant spot.)

Except for man's help how can seeds move?

2. The Challenge or Assignment:

Can you invent a way for a seed to get from its parent plant to some distance away?

You may work alone or in pairs or small groups.

Your idea for how a seed could move should be shown in a model. The model may be made of paper or other materials. The model should demonstrate how the seed can move or be moved by your device.

Use "natural" materials such as a real seed could use. It is not allowed to use materials or systems such as plastics or electric motors.

Your seed transportation device should be your own idea. No fair copying from a seed. But you may consult with one another.

The distance which your invention moves the seed may be anything from a few inches to a few miles.

You may have until ____________(date) to get your model ready for public display.

On that day we will have a SEED DISTRIBUTION FAIR and invite all the seeds to visit it. The visiting seeds will come in from the yard or from the library in botany books or other books about seeds. The visiting seeds will look over your inventions to see if you have any ideas they are not already using. If so, you may be able to teach the seeds something new.

The chances are that no matter how clever your invention is, some seed already has it. Seeds are very "smart". Are you smarter than a seed?

Granted that the seed got the "idea" first for a distribution technique, students are usually willing to play along with the game that they are the inventors and the seeds their customers.

If the students seem to need still further stimulation, you might want to put the following advertisement on the overhead as an example. You might wish to omit the paragraph on the coconut if you think that gives too much away; or leave it in if you think the students need an example.

RAPID TRANSIT CORPORATION FOR SEEDS.

Corporation Engineers: John Ching
Jean Correa

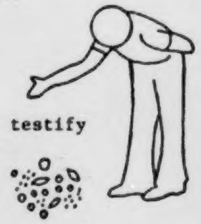
Sales and Service: May Minami
Barbara Young

SEEDS!

Are you in need, of transportation?

See us. We guarantee money-back satisfaction.

Thousands of our satisfied seed customers testify to the excellent products of the



RAPID TRANSIT CORPORATION FOR SEEDS.

Let us give you an example:

Our engineers invented a vehicle for moving a seed from one place to another by putting a life-jacket on the seed and letting it travel by ocean currents. Would you believe a very large, heavy seed bought our idea and is using it very successfully? The seed is the coconut. In the coconut, the life-jacket is made of light-weight straw covered by a waterproof jacket or skin. The jacket survives thousands of miles of ocean travel and lands the big, heavy, nut safe and ready to sprout on distant shores. We deal in other types of distribution equipment also.

Yes, Folks, if you want to know more about transporting seeds in water, on land, and in the air, come see us. We think we can help you.

Open Mondays to Fridays 8:00 am to 2:30 pm. Call 123-4567

3. The students will probably need a few days or a week to prepare and demonstrate their inventions.

4. At the "Seed Distribution Fair" the students may demonstrate their inventions and devices to their classmates.

   Have seeds and books on seeds available for reference to look up the real-life counterparts of the invention. If no seed can be found which is using the student invention, check to see if the student is using a "non-natural" system. Perhaps further seed references can be looked into before deciding that the student invention is indeed a new idea. It may be!

Can you change SEED to COAT in seven steps? Change only one letter at a time in SEED, forming a new word each time, until the seventh word becomes COAT.

Seed Distribution Information . . . Teacher reference only:

SEED	AGENT FOR DISTRIBUTION	DEVICE
acorns, mangos, berries, other edible fruits	birds, man, other animals	Seeds are surrounded by tasty food materials. Birds, man, and other animals eat the fruit or carry it to nest or home and there throw away the seed.
haole koa and some other hard-coat seeds	animals, especially cattle	Seed pod is tasty so animal eats it. Seed coat is hard and protects seed from digestive juices. Seed is expelled in dung and is ready to sprout in a fertilized spot far from parent plant.
sand bur, beggar tick tick, puncture vine.	animals, including man	Seed coat is fitted with hooks, or barbs, which cling to fur, skirts, pants, and are thus carried to another area.
mistletoe, some marsh plants	birds and small animals	Seed coat is very sticky and glues seed to feet of birds or fur of animals who pick the seed off when they clean themselves at another location.
dandelion, milkweed, some thistle, Flora's Paint Brush	wind	Seed coat is very light weight (dehydrated and small) and fitted with tufts of fine hairs which serve as parachutes for carriage by the wind.
maple, moonwart, dock, sandbox tree	wind	Light weight seed has wings or thin flat edges which become a glider so that seed travels some distance while falling.
Russian thistle, and other tumble weeds	wind	When seeds are ripe, entire plant rolls into a stiff, light-weight sphere and detaches itself from its root. Entire plant "ball" is rolled by the wind across the groun ground, dropping seeds as it goes.
coconut, sedges	water	Seed is surrounded by a waterproof air sack or light fibers so that seed floats on rivers or oceans. Coat also protects seed from becoming water-logged.
castor bean, balsam	propulsion	Seed case has elastic fibers which snap when seed is ripe and shoot th the seed some distance away from parent plant.

10-C EXTERNAL FEATURES OF SEEDS. Bands 2 and 3

Introduction.

Seed structure and form is unique to each species of plant. Seed analysts can tell which plant will grow from a seed by identifying its shape, size, color, and surface sculpture.

The features of seeds are worth drawing to student attention, not only as a bit of scientific knowledge, but also as an added dimension for enjoyment of the artistry in nature.

Activities for Bands 2 and 3 are presented together. Facts and discoveries can be much the same for both levels. Band 2 teachers will need to pay more attention to guiding their younger or less experienced students through the procedures. Teachers of the more experienced Band 3 students can spend less time teaching and giving directions, and demand more of student initiative, invention of their own procedures, keeping of data, and analysis and recording of results.

Materials.

-*Seeds*
-*Hand lenses*
-*Notebooks*

Problem:

What different kinds of seeds can you find?

Procedures in Brief.

Teachers may wish to modify the following procedures to suit their individual class needs or campus opportunities.

1. Students collect and bring in seeds.
2. Examine and discuss shape, size, color, texture, appendages.
3. Vocabulary
4. Complete notebook reports on seed types and plants they belong to.

Procedures in Detail.

1. Collection of seeds. This can be accomplished in a number of ways:

Put the students on their own to bring in 1 (or 2 or 5 or 10) kinds of seeds of any kind from whereever they can get them. Remind them that since their recent study of fruits they should know where to look.

Ask each student to bring in a few seeds of one kind from each of the following categories:

1 kind of weed seeds
1 kind of vegetable or fruit seeds from the home kitchen
1 kind of seeds from a tree
1 kind of seeds from a bush or hedge
1 kind of grass seeds; or

Send the students out into the school yard and neighborhood on class time or as homework to collect weed, shrub, grass, and tree seeds. The teacher simultaneously provides a few bags of dried beans, peanuts, sunflower seeds, to give variety to the collection; or

Set up some categories of seeds and challenge the students to find the "prize winning" seed for each category. Categories might be: the smallest seed, the largest seed, the most colorful, the blackest, the smoothest, the shiniest, the roughest, the hardest, the most unusual shape, the one with the fanciest attachments, the one with the most companions in the same pod or capsule, and other categories.

2. In class examine the external characteristics of the various seeds which have been collected. A hand lens will be helpful.

Band 3 students, and perhaps Band 2 students also, can figure out for themselves how to record their data in the notebook reports. Below is a sample data sheet. This format, or a variation of it, may assist students who can't seem to think of an orderly way of their own to arrange data.

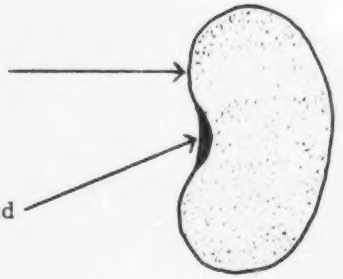
Table 1. The External Appearance of Seeds

SEED NUMBER	PLANT THE SEED WAS COLLECTED FROM	SIZE IN mm	COLOR	ATTACHMENTS	SIZE AND SHAPE	SKETCH	REMARKS
1	Papaya	2 mm in diameter	black	jelly coat around seed	small, bumpy, round		fruit has lots of seeds in cavity
2	Weed under building near room 221	too small to measure	black	none	tiny, smooth, round		very many in capsules in leaf axils
3	etc.						

Help students draw some conclusions. Does observation show that size of seed is related to size of plant? Are all seeds in the same fruit or pod alike? Are all seeds from the same species of plant alike?

Horticulturists can tell which kind of plant will grow by the size, shape, and appearance of a given seed. Can you? Encourage students by saying that they know some already, e.g. they can recognize a coconut, corn, rice, mango, what else?

3. Vocabulary:



The TESTA or the SEED COAT is the thin skin directly covering the seed.

Bean seeds show a HILUM where the seed was attached to the pod.

4. The notebook report may be the formal or the informal type.

Additional Activities.

1. Paste a seed to the front of a card. Write its name on the back of the card.

   A student who can call the name of the plant when looking only at the front of the card gets the card, or gets a score of 1. The students with the most cards or with the highest score has the Highest "Seed I.Q."

2. Count how many seeds are in each of 50 pods of a common bean such as soy beans or haole koa. Make a graph or some other illustration showing how much, if any, the numbers vary among pods of the same species.

3. Make a collection of the kinds of seeds used in costume jewelry, or in macrame, or in art. Display the collection giving the names of the seeds and where they grow.

4. Measure the sizes of seeds obtained from the same pod or fruit. Are they the same or is there a size distribution? Is the same size or size distribution found in other pods or fruits of the same species?

10-D THE INTERNAL ANATOMY OF SEEDS. Bands 2 and 3

Introduction.

If seed germination projects are in progress simultaneously with this study of internal anatomy of seeds, some of the procedures given here can be curtailed or modified in the overlap.

As a topic by itself, internal seed anatomy can be studied as given below, or in some other manner.

Structures diagrammed and mentioned here are limited to those which can be seen with the naked eye and with a hand lens.

Materials.

-Seeds
-Hand lenses

Problem:

What is inside of seeds?

Procedures in Brief.

1. Secure seeds, preferably large ones.
2. Students pursue problem of finding out what is inside.
3. Vocabulary
4. Notebook reports.

Procedures in Detail.

1. Secure seeds. (large sizes)

   You may be able to use some of the seeds already collected for the study of the external anatomy in the last sub-topic; or

   You may wish to have the students collect pods from trees or other sources; or

   Buy several small bags of raw (unprocessed) dried beans of many kinds plus raw peanuts, dried peas, sunflowers, or some packets of flower seeds. Include corn as a sample of a monocot.

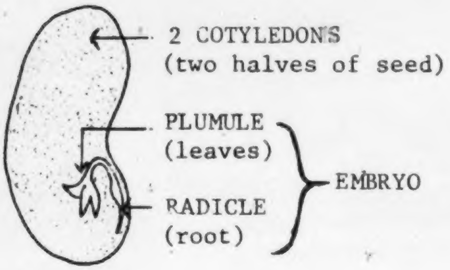
   Soak some of the seeds for several hours or overnight to loosen the testa and soften the seed.

2. Ask the question: What is inside a seed?

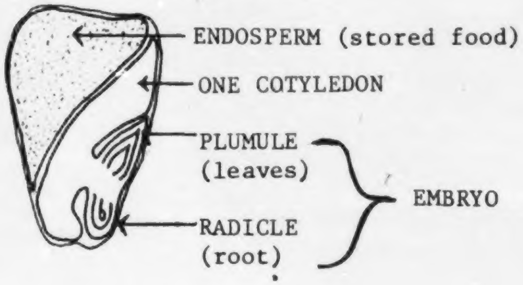
   Students, equipped with a variety of soaked and unsoaked seeds, and with the help of knives, razors, and hand lenses, pursue the problem of what is inside various seeds.

3. Vocabulary

Bean or Peanut (or any Dicot)


2 COTYLEDONS
(two halves of seed)
PLUMULE
(leaves)
RADICLE
(root)
EMBRYO

Corn or Grass (or any Monocot)
(Seed does not split into two halves.)


ENDOSPERM (stored food)
ONE COTYLEDON
PLUMULE
(leaves)
RADICLE
(root)
EMBRYO

In walnuts, the two "wings" of the nut meat are the two cotyledons. In coconut, the white meat is the stored food or endosperm.

4. Notebook reports should show title of sub-topic, problem, data, conclusion.

This concludes the elementary study of plant anatomy.

Some activities in plant physiology and plant identification are found in the Teacher's Guide entitled MORE PLANTS.

See the PROGRAM MANUAL for assistance with record keeping procedures, testing, evaluation, and investigative teaching strategies.